Traffic and Safety Manual

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Acknowledgment

This manual is a compilation of materials developed and collected through the years by current and past traffic engineers. The Division of Traffic and Safety recognizes the efforts by the Region Traffic Engineers to supply the materials but more importantly, the knowledge and experience provided to produce this manual.

Special recognition is given to Katie Knaus for her service to complete the Traffic and Safety Manual. Her work as a Civil Engineering Intern in the Division of Traffic and Safety is greatly appreciated and the publication of this manual is an example of her commitment to the safety of the public.

Robert E. Hull, P.E.
Engineer for Traffic and Safety
Utah Department of Transportation

Introduction

In the United States, nearly 42,000 people lose their lives on the Nation's highways. In Utah alone, nearly 300 people die each year. Each person that dies is a significant loss.

A Traffic Engineer is concerned about the safety of the public, an efficient transportation system, and the mobility of people and the movement of goods and services and the impact of these issues on the community. These principles guide our work as Traffic Engineers. It is the goal of the Utah Department of Transportation, the Division of Traffic and Safety, the Engineer for Traffic and Safety, the Region Traffic Engineers, and all involved with traffic engineering to be successful at accomplishing these ideas. Therefore, it can be said that every UDOT project should be viewed as a safety project.

The intent of this manual is to provide the guidance to achieve these goals and meet the Policy for Traffic and Safety Service 06C-1. The consistent statewide application of the Traffic and Safety Manual, the Manual of Uniform Traffic Control Devices (MUTCD), the Roadside Design Guide, the AASHTO Design Manual, UDOT Standard Drawings and Specifications, and the UDOT School Zone Safety Manual will ensure there is a focused effort by all traffic engineers to this important mission.

The ultimate goal is to eliminate crashes, injuries, and fatalities.

Management Concepts

People, time, and money are all resources available to complete traffic and safety tasks. However, these resources are finite and must be managed wisely to provide their maximum efficiency and effectiveness. A comprehensive management program for traffic and safety activities can be viewed as a cycle of functions that are all interrelated and all dependent on the other functions.

There are four essential components to the management of traffic and safety activities. These four areas are planning, programming, directing, and monitoring.

The planning function provides a strategic direction for the Department that reflects management decisions and goals for safety. Many items are required for this direction to be established. Accurate and comprehensive crash data, crash data analysis, field reviews for operational deficiencies, identification of high accident locations and causes, and input on safety issues in design are a few of these important items.

The programming function uses the information in the planning phase to create programs intended to mitigate safety concerns. The programming function also provides the frame work for traffic engineers to accomplish the safety goals and objectives in an efficient and effective manner.

The directing component involves implementing the programs and objectives established by the

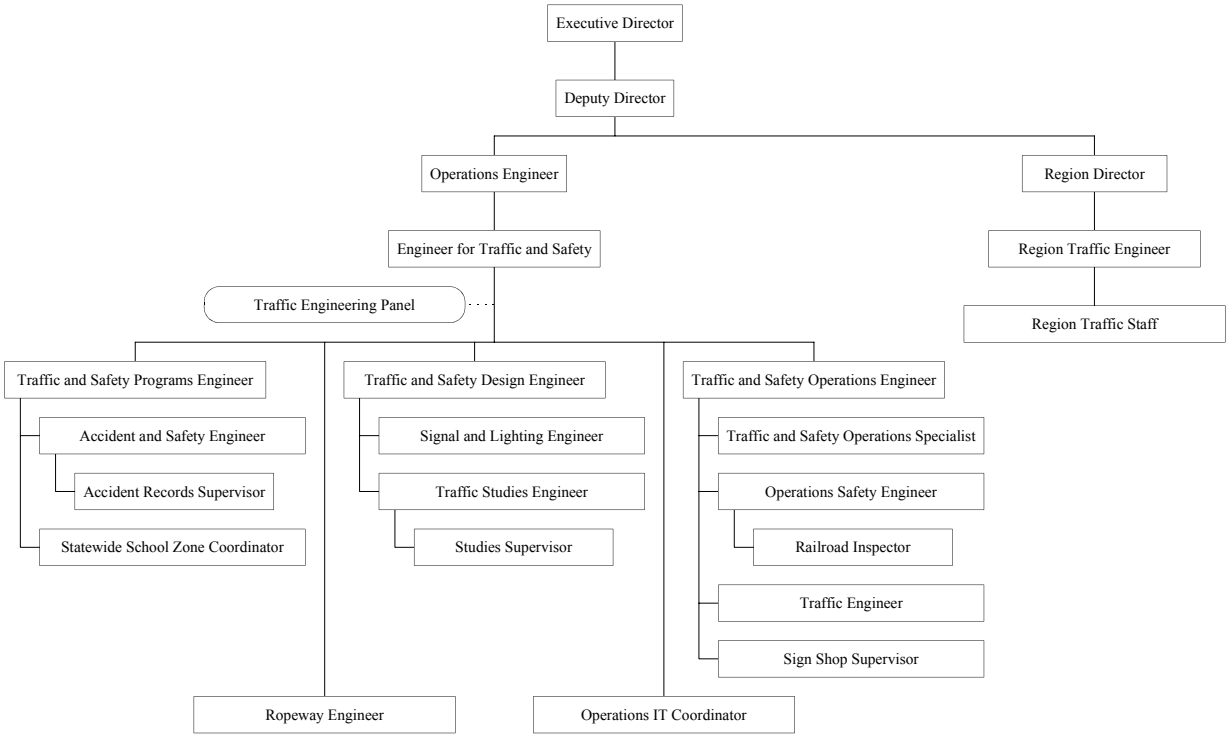
Department. Much of the work completed by the Region Traffic Engineer falls into this category. The ultimate achievement of the safety goals rely on the commitment of the Region Traffic Engineer to adopt and follow through with the safety programs.

Monitoring is the final function of the management cycle. The data collection and evaluation of the safety programs and projects provides the new foundation to the continuing planning phase. Reporting on the effectiveness of the safety programs produces a measure of the success for the Traffic Engineer's commitment to the safety of the public.

Manual Use and Continued Development

The Traffic and Safety Manual should be a living document. It should continue to grow, change, and be revised as time passes and the traffic engineering environment evolves. Therefore, it is expected that the manual will be updated on a continual and consistent basis.

Line of Authority - Organization Chart



Engineer for Traffic and Safety

1. Directs and supervises the following subordinate positions

   Traffic and Safety Programs Engineer
   Traffic and Safety Operations Engineer
   Traffic and Safety Design Engineer
   Ropeway Engineer
   Operations IT Coordinator

2. Develop and review operating policies, long-range plans, operating programs, and budgets.

3. Develops budgets and executes policies and operating programs for the Division of Traffic and Safety.

4. Develops policies, procedures, and guidelines for Regions to use in traffic engineering activities.

5. Directs research for new traffic engineering devices and analysis of existing devices.

6. Develops an organizational staffing plan that is capable of effectively accomplishing statewide traffic engineering goals.

7. Provides traffic engineering and safety expertise to traffic engineers and other department personnel.

8. Oversees the Safety Spot Improvement Program, Federal Hazard Elimination Program, Federal Safety Any Area Program, Signal Construction Program.

The Engineer for Traffic and Safety maintains the following relationships:

1. With the UDOT Operations Engineer.

   A. Accountable for the traffic and safety activities of UDOT including: guidelines, studies, design, operations, and budget.
   B. Advises of significant traffic and safety developments.

2. With other Department Managers.

   A. Coordinates traffic engineering and safety activities.
   B. Jointly develops policies, procedures, and guidelines.
   C. Coordinates with and utilizes their advice and services in executing traffic and safety activities.
   D. Provides information, data, and expertise.

3. With Region Directors and Region/District Staff.

A. Provides studies, information, and data to direct traffic and safety activities.
B. Provides technical and operational assistance.

4. With Federal, Local, and other State Agencies.

A. Coordinates with and provides information, data, and expertise.

Traffic and Safety Programs Engineer

1. Directs and supervises the following subordinate positions:

Accident and Safety Engineer
School Zone Safety Coordinator
Accident Records Supervisor

2. Develops traffic and safety data required to support various UDOT programs and projects.

3. Supervises the Federal Hazardous Elimination Program and Safety Any Area Program.

4. Supervises the analysis of traffic and safety data.

5. Develops safety mitigation plans and programs.

6. Responds to requests for information from the public and other agencies.

7. Supervises preparation and submission of various required annual Traffic and Safety reports.

The Traffic and Safety Studies Engineer maintains the following relationships:

1. With the Engineer for Traffic and Safety and other Traffic and Safety staff.

A. Accountable for the direction and execution of the Division's traffic and safety analysis activities and safety programs.
B. Advises of significant developments and activities of the Traffic and Safety studies section.
C. Furnishes a prioritized list of Hazard Elimination locations.
D. Coordinates and develops studies required for various safety projects.
E. Coordinates design of hazard elimination projects.
F. Coordinates and develops accident data for Operational Safety Reports.

5. With Region and Department staff.

A. Coordinates traffic and safety analysis and makes recommendations for Region staff.
B. Furnishes technical assistance on request.

Traffic and Safety Design Engineer

1. Directs and supervises the following subordinate positions:

   Signal and Lighting Design Engineer
   Traffic Studies Engineer

2. Supervises the State Signal Construction Program.

3. Assists in the plan preparation of all traffic signal and lighting projects.

4. Develops policies and procedures related to traffic and safety design.

5. Oversees 9000 account budgeting and scheduling of projects.

6. Reviews all requests for change in access control.

7. Develops standard drawings and specifications related to signal and lighting design.

8. Supervises studies for highway improvements such as signals, speed zones, lighting, stop signs, and crosswalks.

The Traffic and Safety Design Engineer maintains the following relationships:

1. With Engineer for Traffic and Safety and other Traffic and Safety Staff.

   A. Furnishes a prioritized list of warranted signal locations and projects.
   B. Coordinates and develops studies required for various safety projects.
   C. Accountable for the direction and execution of the Division's studies activities.
   D. Advises of significant developments and activities in signal and lighting design.
   E. Furnishes speed profiles for Traffic Engineering Ordres.

2. With Region and Department staff.

   A. Coordinates traffic studies and makes recommendations to Region staff.
   B. Furnishes technical assistance on request.

Traffic and Safety Operations Engineer

1. Directs and supervises the following subordinate positions:

Operations Safety Engineer
Civil Engineer
Traffic and Safety Operations Specialist

2. Supervises construction of state furnished signs.

3. Conducts classes in work zone safety for Region personnel.

4. Prepare Traffic Engineering Orders for speed limit changes, parking restrictions, other traffic regulations and maintains record for TEOs on all state highways.

5. Prepare Operational Safety Reports for design process.

6. Perform field review of operational deficiencies and make recommendations to Regions.

7. Oversee sign management program.

8. Oversee Safety Spot Improvement Program.

The Traffic and Safety Operations Engineer maintains the following relationships:

1. With Engineer for Traffic and Safety and other Traffic and Safety staff.

   A. Accountable for the direction and execution of the Division's traffic and safety operations activities.
   B. Advises of significant developments and activities of traffic and safety operations section.
   C. Request and review studies concerning operational deficiencies.
   D. Coordinate and provide technical assistance to signal and safety projects.

2. With Region and Department staff.

   A. Provide technical assistance and review of operational deficiencies.
   B. Review work zone traffic issues.

Region Traffic Engineer

1. Directs and supervises the following subordinate positions:

   Varies by Region.

2. Makes field investigations of problems on existing traffic facilities. Plans, coordinates, and directs corrections such as signs, pavement markings, and additional roadway improvements.

3. Determines the feasibility of requests for traffic control devices received from the public or local governmental agencies. Coordinates studies with the Division of Traffic and Safety.

4. Meets with citizen groups and local government agencies concerning state highway traffic control and safety.

5. Establishes priorities for the accomplishment of Region pavement marking and signing programs.

6. Reviews construction and maintenance traffic control plans.

7. Directs and reviews preparation of permanent signing and pavement marking plans for design plans.

8. Prepares written correspondence concerning traffic control and safety on state highway system within Region.

The Region Traffic Engineer maintains the following relationships:

1. With Engineer for Traffic and Safety and other Traffic and Safety staff.

    A. Implements the statewide direction, policies, procedures, programs, and standards established by the Division of Traffic and Safety.
    B. Coordinates traffic and safety activities to ensure consistent statewide application.

Traffic Engineer Panel

The Traffic Engineering Panel is established under authority of Policy 06C-8 for the purpose of advising the Engineer for Traffic and Safety.

Policies and Procedures

Purpose

The purpose of this policy is to define the Department's goal of providing traffic safety and services on the state highway system. The operational effectiveness of the state highway system will continuously be observed and evaluated with regard to traffic safety and service. Safety and service deficiencies on existing routes will be identified and included in programs for improvement to be considered and approved by the Transportation Commission. Improvement programs will provide for correction of deficiencies through highway safety countermeasures, resurfacing, and maintenance.

The Department's highway safety activities will include a continuing program for the reporting of accidents, the analysis of accident record data, and on-the-spot investigations as a basis for developing localized improvements directed toward accident reduction and safer travel.

Policy

This policy applies to all highways under the jurisdiction of the Department. Improvements initiated pursuant to this policy will supplement and compliment the planning, design, and construction of new facilities in regular improvement programs. The Department's objective is to identify and correct existing and potential deficiencies at the earliest possible time, that is, before emergency conditions arise.

Results of the accident analysis program will be used as a basis for evaluating the adequacy of highway geometric standards, as well as a measure of the safety values to be derived from regular improvement programs.

Purpose

In accordance with Sections 27-12-21 and 41-6-21, UCA, the Executive Director of the Utah Department of Transportation shall designate those state highways located in canyon areas of the State of Utah that may not be safely traversed by the public and/or which would tend to create hazardous conditions or hamper road maintenance activities of the Department, unless the vehicle or motor vehicle traversing said highway is adequately equipped with certain safety devices as described hereafter.

Policy

The Division of Traffic and Safety shall maintain and annually publish a listing of those state highways requiring certain safety devices. This listing shall be distributed to UDOT Region/District Offices, the UDOT Community Relations Office, the Utah Highway Patrol, county offices, and local law enforcement officials. When any designated highway is so restricted, no vehicle shall be allowed or permitted the use of said highway, during the period between November 1 and March 31, unless:

a. Said vehicle is equipped with one of the following traction aids:

(1) Steel link chains or have chains in possession; or

(2) Mounted snow tires (it is UDOT's interpretation that any tire which is labeled "M & S" on the sidewall is considered to be an acceptable snow tire); or

(3) Elastomeric tire chains (designed for use with radial tires).

Note: 4-wheel drive vehicles must have a minimum of two mounted snow tires to meet the requirements of this policy.

Note: Radial tires without snow tread do not meet the requirements of this policy.

b. Personnel of the Utah Department of Transportation and/or the Utah Highway Patrol may permit vehicles not equipped with the traction aids defined in the preceding paragraph to travel a designated state highway. However, this determination can only be made by said personnel who are on location and who can ascertain that the vehicle may do so without endangering the public safety or creating a hazard to, or interference with, highway maintenance operations.

Procedures

Determination Where Traction Aids Are Required UDOT 06C-2.1

Responsibility: Region Director/District Engineer

Actions

1. After coordination with the local Highway Patrol Office, will submit a request to the Division of Traffic and Safety for a specific location to have traction aids required as outlined in this policy. A Traffic Engineering Order (TEO) shall be issued by the Division of Traffic and Safety for all approved locations.

2. Shall coordinate with the local Utah Highway Patrol Office to establish working criteria for the adequate enforcement of this policy.

Responsibility: Engineer for Traffic and Safety

3. Shall request the Utah Highway Patrol, or designated local law enforcement agency, to enforce this policy.

4. Shall notify the UDOT Region/District Offices, the UDOT Community Relations Office, the Utah Highway Patrol, county offices, and local law enforcement officials of state highways that are restricted, as outlined above.

Purpose

The purpose of this policy is to control the location and number of freeway median crossovers.

Policy

Freeway median crossovers will be allowed according to the following criteria:

1. Maintenance turn-arounds at interchanges where removal of snow and ice would be significantly facilitated.

2. Official and/or emergency turn-arounds.

    a. Near mid-point where interchanges are 3 to 6 miles apart.

    b. At approximately 3 mile intervals where interchange spacing is greater than 6 miles.

3. Double crossovers (overlapping) at maintenance station, region, or district boundaries.

4. Those crossovers approved as exceptions to the above by the Engineer for Operations.

The Traffic and Safety Division will maintain a list of authorized median crossover locations.

Background

The Utah Department of Transportation constructs and maintains freeway median crossovers (turn-arounds) to facilitate highway maintenance operations. Use of these crossovers by unauthorized vehicles creates a potential safety hazard. In order to minimize this hazard, the Department will control the number of freeway median crossovers.

Procedures

Change In Authorized Freeway Median Crossovers UDOT 06C-4.1

Responsibility: Region Director

Actions

1. Submits a request, including justification, for a change in the number and/or location of freeway median crossovers to the Engineer for Traffic and Safety.

Responsibility: Engineer for Traffic and Safety

2. Performs analysis of request and develops a recommendation relative to the request.

3. Submits Region request together with recommendation to the Engineer for Operations.

Responsibility: Engineer for Operations

4. Approves or disapproves request and transmits decision to the Engineer for Traffic and Safety.

Responsibility: Engineer for Traffic and Safety

5. Passes decision of Engineer for Operations to the appropriate Region Director. If the request is approved, the Region Director is requested to take the necessary action to complete the approved work.

Purpose

The purpose of this policy is to define the proper process for the issuance of Traffic Engineering Orders (TEO's).

Policy

In order to promote motorist, bicyclist, and pedestrian safety and efficiency, the Division of Traffic and Safety will be responsible for continuous observation and evaluation of functional characteristics on the State Highway System, enacting traffic regulations to help achieve this goal.

TEO's specify the authority to establish specific traffic regulations pertaining to (1) directional movements, (2) speed limits, (3) lane restrictions, (4) parking restrictions, (5) pedestrian/bicycle access or restrictions, (6) railroad grade crossing exemptions, and (7) other traffic operations necessary to properly control traffic and enhance safety.

TEO's will be issued only after sound traffic engineering studies have justified their need. Guidelines for the basis of traffic studies will be, but not limited to:

1. Manual on Uniform Traffic Control Devices (MUTCD).

2. Accident Studies.

3. Field investigations.

Parking restrictions will be established when a field review indicates that the allowance of parked vehicles constitutes a visual or highway capacity deficiency. Local jurisdictions will be allowed the right to establish, by ordinance, and maintain turnover-type parking restrictions (one hour parking limit, loading zones, etc.). A request for these restrictions must first be submitted to the Utah Department of Transportation and a TEO issued.

Procedures

Issuance and Control of TEO's UDOT 06C-5.1

Responsibility: Region Director

Actions

1. Receives a request for a TEO from an appropriate elected official, a responsible member of the public, or employees of UDOT. After evaluation and concurrence in the request, coordinates with affected local government agencies and law enforcement officials for their input. Submits request to the Traffic and Safety Division to establish or change a TEO.

Responsibility: Traffic and Safety Studies Engineer

2. Analyzes the feasibility of the request by conducting a study of the need. Such a study may consist of a field investigation, a statistical analysis, or possibly even a field visit with affected parties.

3. Coordinates the study with the Region Director or Region Traffic Engineer.

4. Forwards all justified TEO requests to the Traffic and Safety Operations Engineer.

Responsibility: Traffic and Safety Operations Engineer

5. Prepares necessary documents, assigns TEO number and forwards package to the Engineer for Traffic and Safety.

Responsibility: Engineer for Traffic and Safety

6. Reviews the study, analysis, and recommendations of the Traffic and Safety Studies Engineer.

7. Upon approval, signs the TEO and returns it to the Traffic and Safety Operations Engineer.

Responsibility: Traffic and Safety Operations Engineer

8. Prepares required transmittal correspondence and distributes approved TEO as follows (one copy each):

    a. Central Files

b. Region Operations Engineer or District Engineer

c. Division of Traffic and Safety

d. Utah Highway Patrol

e. Appropriate local governmental agency and local law enforcement agency.

Responsibility: Region Director

9. Verifies that the provisions of the TEO have been executed and then notifies the Traffic and Safety Operations Engineer of satisfactory completion of the TEO requirements.

Purpose

The purpose of this policy is to establish criteria and processes for the handling of requests for highway lighting.

Policy

For the possible increase in efficiency of traffic operations, the Department of Transportation will review requests for the illumination of state highways. Highway lighting will be separated into two categories, the non-freeway or partial access controlled highway, and the freeway or fully controlled access highway.

A. Non-Freeway Highway Lighting

Requests for highway lighting projects should come through the Region/District Offices to the Division of Traffic and Safety. If approved, these projects will be prioritized on the basis of accident rate (accidents per million vehicle miles) and the night time to day time accident ratio. This priority listing and the availability of funds will be the critical factors in determining which highway lighting projects will be funded.

For approved highway lighting projects, the Department will prepare plans, specifications, and estimates and furnish all materials and labor. The local governmental agency having jurisdiction shall pay for operating costs and maintain the lighting system under an appropriate agreement with the Department of Transportation.

B. Freeway Highway Lighting

There shall be no new continuous lighting on the freeway system. Interchange lighting shall be provided after proper engineering evaluation and in accordance with Policy 06C-07. Illumination of the ramp terminals shall be part of the interchange lighting. Projects to reduce and adjust the existing lighting should be approved only after proper engineering evaluation.

Procedures

Installation of Non-Freeway Highway Lighting UDOT 06C-6.1

Responsibility: Traffic and Safety Design Engineer

Actions

1. Receives request for local street lighting project. Requests will be initiated by:

    a. Region Director/District Engineer in concert with local authorities, or

    b. Traffic and Safety Design Section via inventory of community needs.

2. Establishes compliance with warrants. If lighting is warranted, establishes design requirements and preliminary estimate.

3. Coordinates with local government officials; provides information concerning cost of project, local government responsibilities, and various power source alternatives available (i.e., power company owned vs. locally owned); secures letter of understanding from local government.

4. Upon decision of local government as to course of action, Traffic and Safety Design Engineer processes a 9000 Authority for Expenditure document through the Engineer for Traffic and Safety and the Deputy Director. After approval, furnishes design requirements to the Chief Utility Engineer to formalize an agreement with the local government.

5. Prepares plans and specifications in accordance with standard lighting practices.

Responsibility: Chief Utility Engineer

6. Prepares formal agreement for execution by local government and Transportation officials.

Responsibility: Local Government

7. Executes and returns agreement to Chief Utility Engineer.

Responsibility: Chief Utility Engineer

8. Forwards agreement for final execution within Department. A copy of finally executed agreement is sent to the Traffic and Safety Design Engineer.

Responsibility: Traffic and Safety Design Engineer

9. Transmits plans and specifications to local government and notifies them to proceed with lighting installation.

Responsibility: Local Government

10. Submits final costs of completed project to the Traffic and Safety Design Engineer.

Responsibility: Traffic and Safety Design Engineer

11. Inspects project to verify compliance with project plans and specifications and audits vouchers for reimbursement of material costs (if applicable) to local government. Submits final cost to Comptroller Office and approves payment to local government.

12. Notifies Comptroller Office of completion of project so as to close out 9000 Authority by submitting a Termination of Authority Form.

Purpose

The purpose of this policy is to establish the criteria for the lighting of interchanges.

Policy

Interchange lighting has been determined to be an acceptable method of promoting the safe and efficient movement of traffic. Interchange lighting is warranted as specified in the Table included within this policy.

Background

This type of lighting illuminates only the major conflict and decision points at interchanges. Lighting will include three luminaires at the exit ramp area and two luminaires at the ramp terminations (one at the cross street and one on the ramp).

In addition, lighting may be considered in the following areas:

1. Major weave sections.

2. Lane drop areas.

3. Complex alignment changes such as curves greater than 5 degrees.

4. Short gaps of less than 1,000 feet.

5. On ramps and other areas where night time accidents are known to be a problem, and exceed the night time to day time accident ratio of 2.0 to 1.

Interchange Lighting Warrant Table

Average Daily Traf	Less than 1000	1000-3000	3000-5000	> Than 5000
Rural	No	Yes	Yes	Yes
Suburban	No	No	Yes	Yes
Urban	No	No	No	Yes

Definitions

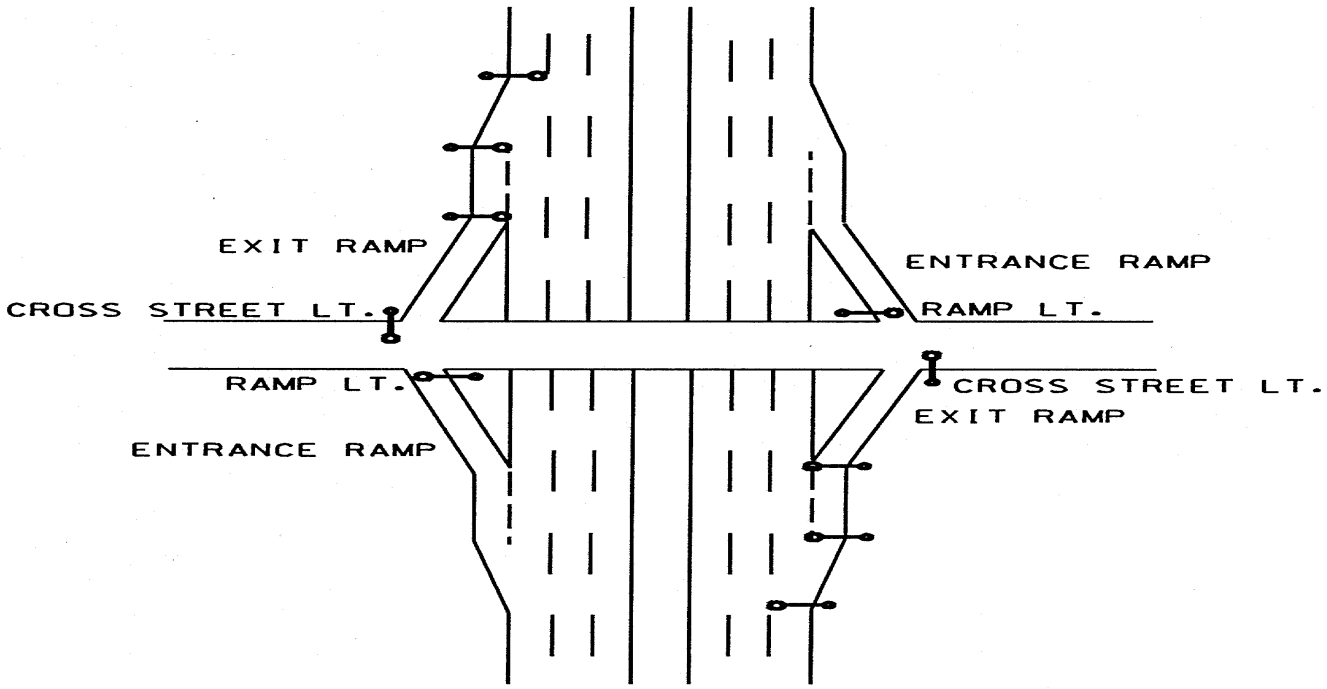
For the purpose of this policy, the following definitions shall apply:

Urban - an area with a boundary set by the responsible state and local officials and having a population of 50,000 or more.

Suburban - an area in which the population in the immediate vicinity is between 10,000 and 50,000.

Rural - those areas outside the urban and suburban area.

INTERCHANGE LIGHTING



Purpose

The purpose of this policy is to create a Traffic Engineering Panel, spell out the Panel membership and organizational structure, and give general guidance regarding the function of the Panel.

Policy

A Traffic Engineering Panel is established for the purpose of:

1. Developing standards and policies for statewide traffic control devices.

2. Developing recommendations for specific traffic and safety problems.

3. Acting as a pool of expertise in traffic and safety matters to include providing data/testimony for tort liability litigation.

4. Developing staffing recommendations for the statewide traffic and safety effort.

5. Overseeing the sign inventory program.

Background

The Traffic Engineering Panel is composed of:

Four Region Traffic Engineers
Three District Representatives
Traffic and Safety Studies Engineer
Traffic and Safety Operations Engineer
Traffic and Safety Design Engineer
Traffic Management Engineer
Transportation Safety Specialist
Engineer for Maintenance (or designee)
Engineer for Traffic and Safety (non-voting)
FHWA Representative (non-voting)
Other participants (non-voting)

The Panel Chairperson shall be appointed by the Engineer for Traffic and Safety with consent of the Engineer for Operations. The Chairperson shall serve for a two year term.

The Chairperson shall distribute to each Panel member and invited participant an agenda outlining the date, time, and place of meeting.

The Chairperson shall make arrangements for a secretary who will prepare a summary of the meeting proceedings to be distributed to all members with the agenda.

A voice vote shall be taken on all items requiring a consensus of the members. When a consensus is not clear after a voice vote, the Chairperson shall call for a roll call vote to be taken.

All recommendations of the Panel shall be evaluated by the Engineer for Traffic and Safety. All approved recommendations shall be implemented by the Regions/Districts upon receipt of appropriate memorandums, instructions, directives, etc. issued by the Engineer for Traffic and Safety or any supervisor above him.

Meetings of the Traffic Engineering Panel should be held quarterly or as often as necessary to serve the purpose of the Panel.

Meetings may be held at various locations throughout the State in order to gain a knowledge and understanding of statewide conditions, to assist in maintaining uniform traffic control statewide and to provide an opportunity to observe experimental installations.

Purpose

The purpose of this policy is to outline the Department's continuing program to insure that all sign installations on the State Highway System conform with the guidelines of the Manual on Uniform Traffic Control Devices (MUTCD).

Policy

To help maintain uniformity in signing; (1) all new permanent sign installations on the non-interstate state highway system shall be reviewed and approved by the Region Traffic Engineer and (2) all new permanent sign installations on the interstate system shall be reviewed and approved by the Traffic and Safety Division.

Existing signs will be monitored, modified and changed as necessary to make sure that they continue to function as intended.

Background

Reference to the Manual on Uniform Traffic Control Devices is essential for the proper use of signs and will ensure that consideration is given to such factors as sign size, color, location, retroreflectivity, message content, and uniformity of application. Signs should be used only where warranted by facts and field studies or at specific times only, or where hazards are self-evident.

Procedures

Monitoring The Existing Inventory Of Signs UDOT 06C-21.1

Responsibility: Region Traffic Engineer

Actions

1. Performs periodic daytime and nighttime inspections of existing signs along the state highways within the Region.

2. Makes notations of any sign problems observed (sign needs to be changed, needs to be replaced, needs to be removed, etc.) and submits a request for specified corrective action to the appropriate Region Maintenance staff member.

Responsibility: Region Maintenance Staff

3. Obtains appropriate signs and makes sure they are in place as specified by the Region Traffic Engineer.

Responsibility: Traffic and Safety Division

4. Provide periodic training for UDOT and Consultant personnel in proper signing techniques and proper sign inspection processes.

Purpose

The purpose of this policy is to define the use of overhead sign lighting on freeways.

Policy

The Department shall install lighting on freeway to freeway overhead guide signs. Where there are overhead exit directional signs, these shall also be illuminated. If an overhead sign qualifies for lighting, all signs on the structure shall be illuminated. UDOT may also consider the installation of freeway overhead guide sign lighting at other locations as approved by the Engineer for Traffic and Safety.

Establishment Of Speed Limits On State Highways UDOT 06C-25

Effective: October 4, 1991 Revised: March 17, 1999

Purpose

The purpose of this policy is to define the process for the establishment of speed limits on state highways. See Policy 06C-61 for the establishment of temporary speed limits in work zones.

Policy

It is the policy of the Utah Department of Transportation to establish speed limits on state highways on the basis of an engineering and traffic investigation in accordance with the most recent edition of the Manual on Uniform Traffic Control Devices (MUTCD). Speed zone studies will be conducted upon request of the Region Director/District Engineer, the Region Traffic Engineer, or other recognized authority. In conducting a speed zone study, input from local government officials will be considered. Establishment of speed limits may not violate the provisions of Sections 41-6-46 and 41-6-47 of the Utah Code Annotated.

The statutory speed limit shall be based on the 85th percentile speed rounded to the nearest 5 mph increment, and giving consideration to:

1. Road surface characteristics, shoulder condition, grade, alignment, and sight distance.

2. Roadside development and culture, and roadside friction.

3. Safe speeds for curves or hazardous locations within the zone.

4. Pedestrian activity, parking practices, and other traffic.

5. Reported accident experience for the most recent 3 year period.

In establishing the statutory speed limit, consideration may be given for a speed limit below the 85th percentile speed based on the above factors. Any reduction below the 85th percentile speed shall not exceed 10 mph when the 85th percentile speed is greater than 45 mph and 5 mph when the 85th percentile speed is less than, or equal to, 45 mph. The reduced speed limit shall be reviewed with local authorities.

Whenever the speed limit has been reduced below the 85th percentile speed as a result of the engineering and traffic investigation, another study will be made from six to twelve months later. If necessary, the speed limit will then be adjusted to ensure that it is not more than 5 mph below the 85th percentile speed. Local authorities will be advised before any changes are made.

In conducting the study, if no reduction of the speed limit is recommended and local authorities are not satisfied with the results of the Department study, an appeal process is available and is described later in this policy/procedure. All appeals must be substantiated by facts and reliable data.

Procedures

Establishment Of Speed Limits On State Highways UDOT 06C-25.1

Responsibility: Region Director/District Engineer or Region Traffic Engineer

Actions

1. Region Director/District Engineer or Region Traffic Engineer receives a request from a local government to perform a speed zone study. This request from the local government should include reasons why it is felt that the speed limit should be changed together with recommendations as to what the speed limit should be.

2. Requests the Engineer for Traffic and Safety to conduct the necessary study.

Responsibility: Engineer for Traffic and Safety

3. Upon receipt of request from a Region/District for a speed limit study, requests that the Traffic and Safety Studies Engineer performs the necessary study.

Responsibility: Traffic and Safety Studies Engineer

4. Initiates field study to include three year accident history, roadway geometry, roadside developments throughout the highway segment, pedestrian activity, school crossings, 85th percentile speed, and other considerations.

5. Evaluates data to determine appropriate speed limit in accordance with MUTCD.

6. Prepares study report and submits recommendations with appropriate supporting data to the Region Director/District Engineer.

Responsibility: Region Director/District Engineer

7. Informs local government of study results. Schedules meeting with local government officials, if necessary. Requests Engineer for Traffic and Safety to issue appropriate T.E.O.

Responsibility: Local government agency (appeal process)

8. May appeal the speed study recommendations to the Department Executive Staff. All appeals shall be based on violation of Department Policy or MUTCD Standards.

Responsibility: Engineer for Traffic and Safety

9. Issues required T.E.O.

Responsibility: Region Director/District Engineer

10. Executes necessary steps to comply with T.E.O. including preparation and placement of new speed limit signs or relocation of existing signs.

Camping Signs On State Highways Other Than Freeways

UDOT 06C-29

Effective: July 13, 1973 Revised: August 17, 1998

Purpose

The purpose of this policy is to define the acceptable use of camping signs on state highways other than freeways.

Policy

Signing for camping may be installed on state highways, other than freeways if the following services and criteria are met:

1. Camping facility is located within five miles of the state highway.
2. Camping facility is operated twenty-four hours each day, seven days each week.
3. Camping facility is licensed by the appropriate public agency.
4. A minimum of twenty camping spaces are available.
5. Drinking water and modern sanitary facilities are available.
6. Adequate parking is available.
7. Removable signs are available if operated seasonally.

Advance guide signing shall consist of the camping symbol and the legend "Turn Off - 1/2 mile". Signing at the turn-off shall consist of the camping symbol, a directional arrow, and the distance to the campground. Names of campgrounds or operating agencies shall not be shown. The standard symbol for camping shall be as specified in the Manual on Uniform Traffic Control Devices (D9-3, tent symbol or D9-3a, trailer symbol). The tent symbol shall be used at locations where only tent facilities are available.

Recreational And Cultural Interest Signing On Highways Other Than Freeways And Guide Signing For Recreational Information Centers

UDOT 06C-30

Effective: January 9, 1970 Revised: September 30, 1999

Purpose

The purpose of this policy is to define the proper use of signing for recreational/cultural interest facilities and for recreational/cultural information centers on state highways other than freeways.

Policy

UDOT, by Administrative Rule, has adopted the Manual on Uniform Traffic Control Devices (MUTCD) as its standard for warranting and applying all traffic control devices. The MUTCD provides specific criteria for guide and destination signing on highways. The MUTCD also recognizes the need for recreational and cultural interest signing and provides general guidelines for this type of signing. This policy is adopted in recognition of the need for an orderly and uniform application of recreational and cultural interest signing.

Signing for major recreational/cultural interest destinations on highways other than freeways will be allowed under the guidelines as prescribed in the MUTCD and this policy.

1. Signs for recreational/cultural interest destinations shall not be installed without prior approval of the Division of Traffic and Safety.

2. Signing for recreational/cultural interest destinations is considered supplemental to overall signing and may not be installed where there is insufficient longitudinal spacing from adjacent signing of higher priority.

3. Signs for recreational/cultural interest destinations shall be located in advance of the closest intersection that provides the most direct and best route to the destination(s). Normally, a sign at the cross street is all that is necessary to provide direction to the destination(s) that may be reached from the intersection. However, an additional advance sign may be located 1/4 to 1/2 mile from the intersection.

4. The recreational/cultural interest destination signs may contain up to three destinations. In the event there are more than three qualifying destinations, the three which create the greatest traffic demand should be shown. Selection of the qualifying destinations shall be coordinated with the local governmental agency.

5. A confirmation mileage sign should be installed on the cross street for destinations further than 1 mile from the intersecting route.

When the destination is not located on the crossroad, or is not readily visible from the crossroad, trailblazers shall be installed.

When the destination is not located on a state highway, signing shall not be installed for the facility until the local governmental agency has installed appropriate trailblazing signs.

The access road(s) to the facility must be traversable under normal weather conditions by 2-wheel drive passenger vehicles.

6. Except for major traffic generators, the destination should be located no more than 25 miles from the highway intersection.

   Signing may contain the name of the recreational or cultural interest destination with a maximum of three symbols showing the types of recreation available.

   Signing for a seasonal destination shall be covered or removed at the end of each season.

7. Those communities, or other geographical areas, which may contain several recreational/cultural interest facilities are encouraged to establish recreational/cultural information centers to which the Department may guide interested parties from the State Highway System.

   These recreational/cultural information centers are to be reasonably accessible from the State Highway System and shall afford adequate parking facilities for interested parties. These centers shall be staffed not less than eight hours per day, seven days per week and shall be sponsored by an impartial group representing the area. These centers shall provide telephone, rest room, and drinking water facilities to visitors or shall provide access to such facilities.

   Any community developing such a center, meeting the requirements presented above, shall qualify for recreational/cultural interest guide signing from the State Highway System to the center. The signing to be provided by the Department shall be white legend on brown background.

   Isolated recreational/cultural facilities in rural areas may be signed specifically; for example, "Ski Area" or "Camping Area".

8. Destinations which may be signed for include:

   A. Recreational

      (1) National Parks
      (2) National Forests
      (3) National Recreation Areas
      (4) National Monuments
      (5) State Parks
      (6) Lakes/Dams and other Geographical Areas
      (7) Ski Areas
      (8) Other Recreational Facilities/Areas

   B. Cultural

      (1) National Historic Sites
      (2) National Landmarks
      (3) Museums of Regional Significance
      (4) Civic Centers
      (5) State and County Fairgrounds

9. Destinations which normally should be excluded from highway signing include:

      (1) Churches
      (2) Libraries
      (3) Clubs
      (4) Elementary, Middle, Jr. High, and High Schools
      (5) Shopping Centers
      (6) Private Businesses
      (7) Subdivisions
      (8) City and County Parks
      (9) Police/Fire Stations
      (10) Post Offices
      (11) Court Houses
      (12) Privately-owned Museums
      (13) Theaters
      (14) Cemeteries
      (15) Prisons
      (16) Power Plants
      (17) Seminaries
      (18) Historical Homes or Buildings

Purpose

The purpose of this policy is to define freeway business loops and spurs which are eligible for applicable signing.

Policy

Business loops or spurs will only be considered where less than four interchanges are provided to an urbanized area.

Business loops shall not exceed six miles in length and shall not impose substantial out-of-direction travel for through traffic. Business spurs shall not exceed three miles in length.

A business loop or spur shall not be established unless all of the following services are available:

1. At least two automotive service stations that operate 16 hours per day, seven days per week, and offering fuel, oil, lubrication, tire repair, rest rooms, drinking water, and telephone.

2. A restaurant serving three meals per day, seven days per week, and licensed by the appropriate public agency.

3. At least ten rooms of motel or hotel space with private baths.

4. A drug store, employing a licensed pharmacist, open at least 12 hours per day, six days per week.

Those cities which qualify for business loop or spur signing are as follows:

Business Loop

I-15

Beaver
Cedar City
Fillmore
Nephi
Parowan
Spanish Fork
St. George

I-70

Green River
Richfield

I-84

Henefer
Morgan
Tremonton

I-80

Wendover

Business Spur

I-15

Payson
Springville

I-80
Coalville

I-70

Salina

I-84

None

Signing Of Tourist Information Centers And Rest Areas On Freeways And Expressways

UDOT 06C-34

Effective: May 21, 1976 Revised: March 17, 1999

Purpose

The purpose of this policy is to define the process for placing advance signing for tourist information centers that are located in rest areas on freeways.

Policy

Tourist information centers located in rest areas on freeways may receive signing in accordance with the following criteria:

1. Must be staffed for continuous operation eight hours a day, seven days a week. If a tourist information center is operated on a seasonal basis, the tourist information sign must be covered or removed during the off season.

2. The name of the operating agency shall not be shown on any of the advance signing.

3. The signs shall have white legend and border on a blue background.

4. The advance signing for a tourist information center in a rest area shall be the same as Figure 1, and either of the two signs in Figure 2. The gore rest area sign shall not have tourist information center on it.

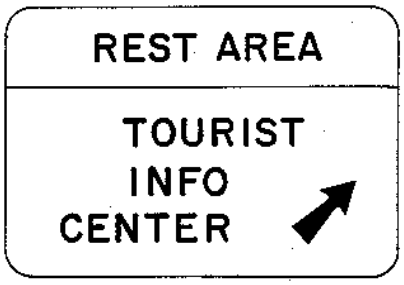
5. If advanced rest area signing is already in place, the tourist information sign as pictured in Figure 4 shall be attached to the existing rest area signing (Figure 3) providing it does not destroy the breakaway effect of the existing sign.

Where tourist information centers are located in excess of ten miles from any state line, a conformational mileage sign (Figure 5) may be installed near the state line, giving the mileage to the first tourist information center located on that route.

12' x 8.5' WHITE/BLUE

Figure 1

12' x 8.5' WHITE/BLUE



12' x 8.5' WHITE/BLUE

Figure 2

10' x 5' WHITE/BLUE

10' x 5' WHITE/BLUE

10' x 5' WHITE/BLUE

Figure 3

10' x 4.5' WHITE/BLUE

Figure 4

10' x 4.5' WHITE/BLUE

Figure 5

Curb And Pavement Marking For Parking Control UDOT 06C-41

Effective: February 11, 1994 Revised: March 17, 1999

Purpose

The purpose of this policy is to define the proper process for the marking of curbs and pavements for parking control.

Policy

Local authorities, except for maintaining existing markings, may not place new or extend existing curb painting on state highways without Department approval.

Special uses (i.e., truck loading zones, bus and taxi zones, passenger loading zones, etc.) may be established on state highways upon request from local authorities and approval by the Department. Curbs painted for these types of special uses shall be yellow in color and shall only be used in conjunction with appropriate signs.

The Department may allow local authorities to post parking time restrictions on state highways by installing (1) signs only or (2) parking meters in conjunction with signs. Curbs in these areas shall not be painted.

Curb markings are supplemental to "No Parking" signs and may not be used without the appropriate signing except in the below defined statutory zones. The following statutory "No Parking Anytime" zones may be indicated by red curb markings:

a. Within 15 feet of a fire hydrant

b. Within 20 feet of a crosswalk

c. Within 30 feet of an intersection

d. Within 20 feet of a fire station driveway

e. Within 50 feet of a railroad crossing

f. Wherever parking would encroach upon a traffic lane

Parking messages shall not be stenciled or otherwise painted on curbs. Painted parking stalls may be installed by local authorities with Department approval.

Procedure For The Establishment Of Pass/No Pass Zones

UDOT 06C-42

Effective: October 30, 1981 Revised: March 17, 1999

Purpose

The purpose of this policy is to define the process for the establishment of pass/no-pass zones on two-lane state highways.

Policy

In order to help promote motorist safety, the Division of Traffic and Safety will establish and monitor the pass/no-pass zones on two-lane state highways of the State Highway System.

Procedures

Establishment of Pass/No-Pass Zones UDOT 06C-42.1

Responsibility: Region Director/District Engineer

Actions

1. Sends requests to the Engineer for Traffic and Safety for pass/no-pass zone studies.

Responsibility: Engineer for Traffic and Safety

2. Reviews and forwards requests for pass/no-pass zone studies to the Traffic and Safety Studies Engineer.

Responsibility: Traffic and Safety Studies Engineer

3. Performs pass/no-pass zone studies and forwards study results to the appropriate Region Director/District Engineer, for consultation with the Region Traffic Engineer.

Responsibility: Region Preconstruction Engineer

4. For two-lane highways, will make sure that all plans that modify, or establish new horizontal or vertical alignments shall have proper pass/no-pass zones indicated on the plan sheets. These pass/no-pass zones shall be determined in accordance with current AASHTO/FHWA requirements.

Responsibility: Region/District Maintenance Paint Crew

5. Will maintain pass/no-pass zones by periodic painting of the appropriate no-pass lines along the pavement centerlines of two-lane state highways.

Purpose

The purpose of this policy is to define the process for the warranting, programming, designing, and installing of traffic signals. A set of application criteria is needed in order to responsibly and uniformly treat requests for traffic signal installations. This criteria must assure that traffic signals serve the public interest considering both safety and the efficient management of traffic. To this end, the Traffic and Safety Division will evaluate the operational characteristics of intersections on the State Highway System.

Policy

UDOT has, by Administrative Rule, adopted the Manual on Uniform Traffic Control Devices (MUTCD) as the Utah manual for a uniform system of traffic control devices.

Included herein are procedures for determining when traffic signals are warranted together with an explanation of plan preparation and installation of traffic signals on state highways. UDOT assumes maintenance and repair of all the traffic signals on the State Highway System and bears all expenses for their operation.

When an intersection is found to meet one or more warrants according to the MUTCD and Procedure 06C-51.1, the location may be considered for traffic signal installation as part of a future signal program. The meeting of a traffic signal warrant does not guarantee installation of a traffic signal. Other factors such as roadway geometry, traffic management, and safety shall be considered.

Installation of new traffic signals or modifications, deletions, or additions to existing traffic signals which affect the number of traffic lanes or the number or the location of signal heads may be implemented only after a traffic engineering study and field review show a need. The Engineer for Traffic and Safety shall approve all such modifications, deletions, and additions prior to their implementation.

Modernization of existing signals may be accomplished only at locations where justifiable warrants exist in conformance with the MUTCD and Procedure 06C-51.2. Signals that are no longer warranted should be removed. When a private development or another government agency necessitates the installation or modification of a traffic signal, the cost of the signal project shall be borne by the developer or appropriate government agency.

Funds from local government agencies or from private sources may be used to expedite the installation of newly warranted traffic signals or the upgrading of existing traffic signals.

When a private driveway or commercial access is requested to be signalized, the following conditions shall be met before the signal system is designed and installed:

1. The intersection created by the existing driveway or commercial access and the state highway shall meet the signal warrants outlined in the MUTCD. Projections of traffic volumes shall not be used unless verified and accepted by the UDOT Program Development Director.

2. The developer or local authority shall fund the total cost of the signal installation, including the design, right of way acquisition, and all associated roadway modifications.

3. The driveway or driveways (if on both sides of the state highway) shall be constructed to UDOT roadway intersection standards, with the cost to be borne by the developer or local authority.

4. The driveway shall become a dedicated public street with restricted access for a minimum of 200 feet into the developer's/owner's property, or a distance determined by an engineering study that is performed, or approved, by the Traffic and Safety Division.

5. An additional access from the development to another street or highway shall be provided.

If a commercial access does not meet the signal warrants, but is opposite a dedicated public street which meets the warrants, UDOT will install signal pole foundations and detection loops for the driveway only if the driveway is reconstructed to UDOT roadway intersection standards.

Procedures

Warranting a New Signal UDOT 06C-51.1

Responsibility: Region Director

Actions

1. Requests the Engineer for Traffic and Safety to conduct a traffic signal study.

Responsibility: Engineer for Traffic and Safety

2. Reviews or initiates request and forwards it to the Traffic and Safety Studies Engineer.

Responsibility: Traffic and Safety Studies Engineer

3. Initiates field studies and generates accident history reports.

4. Analyzes data collected to determine if a traffic signal warrant criteria is met.

5. If traffic signal warrant criteria is met, holds final warranting meeting with representatives from Traffic Studies, Traffic and Safety Design, Region (typically Region Traffic Engineer and sometimes Region Preconstruction). The purpose of this meeting shall be to determine if the location should be put on the warranted construction list, or if major highway modifications are necessary in conjunction with or in lieu of a signal installation. Items normally considered at the meeting include: safety, traffic management, geometric feasibility, and environmental concerns.

6. Conducts traffic simulations if determined to be necessary.

7. Places location in one of the four following categories based on the result of the signal warrant study and final warranting meeting:

   (a) Does not meet a minimum warrant for signalization.

   (b) Meets a minimum warrant and does not have major geometric problems or environmental concerns. Project concept satisfies safety and traffic management concerns. (Recommended for installation.)

   (c) Meets a minimum warrant, but is not recommended for signal installation based on safety concerns or traffic management.

   (d) Meets minimum warrant, but requires major roadway modifications to

accommodate signal.

8. If location is not warranted or not recommended for signal installation, notifies Region Director and outlines results of study and project scope meeting, if held.

9. If location meets a minimum warrant, has no major geometric problems, and satisfies safety and traffic management concerns, notifies Region Director that the location is considered warranted and provides appropriate recommendations.

Responsibility: Region Director

10. Reviews recommendations and provides comments to the Engineer for Traffic and Safety.

Responsibility: Traffic and Safety Studies Engineer

11. If warranted and Region Director concurs, adds location to warranted signal construction list and notifies Traffic and Safety Design Engineer.

Responsibility: Traffic and Safety Design Engineer

12. Packages signals from the warranted signal construction list, establishes a 9000 authority to the package, notifies Program Development of 9000 authority, and assigns each package to a Project Manager to oversee design of the package of signals.

Responsibility: Traffic and Safety Studies Engineer

13. If the signal installation meets a minimum warrant but requires major roadway modifications to accommodate a signal, forwards recommendations to Region Director for consideration as part of a future roadway project.

Responsibility: Project Manager

14. Coordinates all design and reviews in accordance with Procedure 08-1.

Responsibility: Region Construction Office

15. Conducts final inspection to verify compliance with project plans and specifications. The Region Traffic Engineer and the Signal Inspector of the ITS Division shall be invited to this inspection.

Responsibility: Traffic and Safety Design Engineer

16. Notifies accounting staff of contract completion to close out 9000 authority project account number.

Modifying an Existing Traffic Signal UDOT 06C-51.2

Responsibility: Traffic and Safety Studies Engineer

Actions

1. Receives request from the ITS Division Chief, the Engineer for Traffic and Safety or a Region Director.

2. Reviews request with respect to safety and, if in agreement with the modification, outlines scope of work on the "Request for Traffic Signal Modification" form and forwards to the Traffic and Safety Design Engineer.

Responsibility: Traffic and Safety Design Engineer

3. Reviews proposed changes and, if in agreement with the changes, packages signals that are to be modified, notifies Program Development of 9000 authority, and assigns each package to a Project Manager to oversee design of the package of signals.

4. Completes and signs "Request for Traffic Signal Modification" form. If work is to be completed by state forces, follow steps 5 - 7 below. If work is to be completed by outside contractor, follows steps 9 - 16 in Procedure 06C-51.1.

Responsibility: Traffic Management Engineer

5. Reviews "Request for Traffic Signal Modification" form and, if agreeable, schedules work.

Responsibility: Signal Supervisor

6. Notifies Region Traffic Engineer of work scheduled. Supervises work and signs off request when work is complete. Forwards signed-off request to Traffic Management Engineer.

Responsibility: Traffic Management Engineer

7. Notifies Traffic and Safety Studies Engineer and Traffic and Safety Design Engineer when work is complete.

Purpose

The purpose of this policy is to define the proper process for the establishment of temporary regulatory speed limits in work zones on all state highways.

Policy

Existing speed limits shall remain in effect through work zones on state highways except where those work zone activities would create a condition that would be aggravated by a retention of the existing speed limits. When such a condition occurs, the speed limit may be temporarily reduced 20 MPH on roads greater than or equal to 60 MPH, or 15 MPH on roads less than 60 MPH. All speed reductions that would exceed those stated shall be approved by the Division of Traffic and Safety.

Advisory and regulatory speed changes shall only be used during impacted times and in impacted areas. Work zone may be temporarily changed by one of the two following methods.

1. Conditions experienced in the field by either maintenance or construction work forces, a temporary regulatory speed limit may be set by the Region Director, after consultation with the Region Traffic Engineer. That temporary regulatory speed limit shall be in effect no longer than 15 calendar days. A one-time 15 calendar day extension of the temporary regulatory speed limit may be granted by the Region Director, after consultation with the region traffic Engineer. If the temporary regulatory speed limit, established by the Region Director, is to stay in effect longer than 30 calendar days, a formally approved TEO will be required.

2. A project under design, with a temporary regulatory speed limit, may be established as a part of the traffic control plan. Temporary regulatory speed limit signs shall not be erected until all appropriate work zone signs have been placed in accordance with the approved traffic control plans.

Definitions

TEO

A Traffic Engineering Order (TEO) is a document that specifies the authority to establish specific traffic regulations pertaining to directional movements, speed limits, parking restrictions, and railroad grade crossing exemptions. See Policy UDOT 06C-05 for further information regarding TEO's.

Procedures

Existing Work Zones UDOT 06C-61.1

Responsibility: Construction/Maintenance Crew Supervisor

Actions

1. Determines the need for a temporary regulatory speed limit.

2. Prepares recommendation for the temporary regulatory speed limit and submits it to the region Traffic Engineer for consideration.

Responsibility: Region Traffic Engineer

3. Considers recommendation and submits to the Region Director with comments.

Responsibility: Region Director

4. Considers recommendation together with comments of Region Traffic Engineer and approves request if such action is determined to be appropriate. Said approval shall be for a 15 calendar day period.

Responsibility: Construction/Maintenance Crew Supervisor

5. Shall determine impacted areas and impacted times and make any signing changes that are necessary. This may require removing or covering any sign that is not appropriate or consistent with the construction impact.

Responsibility: Region Traffic Engineer

6. Periodically reviews work zone with temporary regulatory speed limit to make sure conditions are acceptable. Unacceptable conditions may require changing the temporary regulatory speed limit. Also determines if a 15 calendar day extension to the original temporary regulatory speed limit is appropriate.

7. Makes recommendation to the Region Director regarding a 15 day calendar day extension or to request the issuance of a TEO to cover a longer period.

Responsibility: Region Director

8. Considers recommendation of Region Traffic Engineer and, if appropriate, approves request for 15 calendar day extension or transmits a request for a TEO to the Division of Traffic and Safety.

Responsibility: Traffic and Safety Division

9. For justifiable requests, issues a TEO for a temporary regulatory speed limit within 7 calendar days of receiving said request.

Projects In Design UDOT 06C-61.2

Responsibility: Design Engineer

Actions

1. In consultation with the Region Traffic Engineer, makes a determination that a temporary regulatory speed limit is appropriate and necessary for a project in design.

2. Designs or reviews traffic control plan submitted by contractor.

3. Submits project/traffic control plans to Traffic and Safety for review.

Responsibility: Traffic and Safety Division

4. During design review, verifies that proposed traffic control plan is adequate. Sign-off on the traffic control plan indicates approval of any temporary regulatory speed limits shown therein.

Purpose

The purpose of this policy is to define the criteria and process for approval of overhead school flashers.

Policy

To increase motorist awareness and to promote safety at school zones on multi-lane state highways, the Department will consider the installation of overhead school flashers at reduced speed school zones when an engineering study indicates that the criteria for such installations are met. Overhead flashers shall not be installed at reduced speed school zones where the school crossing is at a signalized intersection. At other locations, the following criteria shall be met:

(a) The state road adjacent to the school zone shall be a multi-lane highway, i.e., two or more approach lanes.

(b) The reduced speed school zone shall be on a designated school route plan.

(c) The following system of points shall be applied:

POSTED SPEED LIMIT

30 mph or 35 mph . . . . . 1 point

40 mph or 45 mph . . . . . 2 points

50 mph or 55 mph . . . . . 3 points

NUMBER OF APPROACH LANES

2 lanes . . . . . 1 point

3 lanes . . . . . 2 points

over 3 lanes . . . . . 3 points

The criteria will be met when any combination of the above parameters totals 3 or more points or when visibility of a side mounted school flashing sign is obscured due to fixed objects, parked vehicles, vegetation, or other features that cannot be removed in a practical manner.

Procedures

Installation of Overhead School Flashers UDOT 06C-72.1

Responsibility: Local agencies

Actions

1. Request that the Department, through the appropriate Region/District Office, analyze the need for an overhead school flasher at a specified location.

Responsibility: Region/District Office

2. Shall review request to determine if the criteria explained in this policy are met. If criteria is met, shall submit data to the Traffic and Safety Division.

Responsibility: Traffic and Safety Division

3. Shall establish priorities and include qualifying locations in future programs as funding becomes available.

4. Shall initiate agreements on each location identifying the following:

   (a) Design and installation shall be the responsibility of the Division of Traffic and Safety.

   (b) The Department shall be responsible for maintaining the overhead school flashers.

   (c) All power and operating costs shall be the responsibility of the local agency.

   (d) Crossing guards shall be furnished and trained by the local agency as required by the Manual and Specifications on School Crossing Zones.

   (e) The Department shall contribute not more than 1/2 of the total cost of design and construction. The balance of the funding will come from local agencies, school districts, or private sources. The Department will not contribute to the cost of an overhead school flasher for new schools.

Purpose

The purpose of this policy is to define the criteria and process for approval of school pedestrian overpass structures.

Policy

To promote pedestrian and motorist safety, the Department may consider the installation of school pedestrian overpass structures at locations where pedestrian volume together with vehicle speed and volume create potentially excessive conflicts. When considering the installation of a school pedestrian overpass, the following analysis shall be made:

1. The local school board shall evaluate their school routing plan and show that changing school boundaries to coincide with major highways, or providing an alternate means of transportation to satisfy the need for a structure would be impractical.

2. Provide school crossing zones in accordance with the most recent version of the Manual on Uniform Traffic Control Devices (MUTCD) and the Manual and Specifications on School Crossing Zones.

3. If steps 1 and 2 above are not effective, and the pedestrian signal warrant is met as outlined in the MUTCD, a traffic signal may be installed at the intersection where pedestrians are expected to cross the facility. The Department shall install signals only on state highways and as funds are available.

4. A structure may be considered to be warranted if steps 1, 2, and 3 above have been followed and there is still a need to eliminate conflicts between pedestrians and motor vehicles and all of the following criteria are met:

    a. Based on pedestrian demand, the structure must be needed for at least the next 5 years.

    b. It must be practical to install a barrier to channelize the pedestrian movement.

Funding

Where a pedestrian overpass structure is warranted following steps 1 through 4, the Department may participate in the cost of design, right-of-way acquisition, utility relocation, and construction at the following rates:

1. On existing alignment - 50% of the total cost.

2. On new highway alignments - 75% of the total cost.

The balance of funding must come from local agencies, school districts, or private sources.

If Federal-aid funds are available and eligible, the local agency would be responsible for the matching funds. If the State Legislature appropriates funds for a specific overpass structure, the local agency or other sources are responsible for the balance of funding above the appropriated level.

Procedure For UDOT's Approval To Provide Exemption At Railroad Crossings

UDOT 06C-83

Effective: August 14, 1987 **Revised: September 30, 1999**

Purpose

The purpose of this policy is to define the process of "Exempting At-Grade Railroad Crossings" in accordance with Section 41-6-97(3) of the Utah Code Annotated.

Policy

While making sure not to jeopardize the safety of the affected transportation systems, the Department will consider requests to "Exempt" at-grade railroad crossings consistent with State Motor Carrier Safety Regulation Subpart B - 392.10(b)(5). "Exempt" signs for industrial or spur-line railroad crossings shall only be erected by, or with consent of, the Department.

Procedures

Exempting At-Grade Railroad Crossings UDOT 06C-83.1

Responsibility: Railroad Safety Coordinator

Actions

1. Receives application from Motor or Rail Carrier industry, school districts or other public sources for exemption from stopping of certain vehicles at at-grade industrial or spur-line crossings.

2. Coordinates with Diagnostic Team to verify adequacy of current protection devices. Makes evaluation based on established accident prediction formulas including an analysis of truck (hazardous materials) and bus traffic. Secures response from railroad company and appropriate local governments.

3. Coordinates with the Attorney General for preparation of public notice, "Notice of Intended Action." Assures action is officially approved on the date specified by the notice.

4. Distributes Proof of Publication to involved parties.

Responsibility: Engineer for Traffic and Safety

5. Issues Traffic Engineering Order establishing "Exemption" and/or approves changes (safety measures) and signing to be installed by the Region/District maintenance forces.

Responsibility: Railroad Safety Coordinator

6. Establishes liaison with appropriate Region/District for final inspection of at-grade railroad crossing and provides for inventory update.

Signing

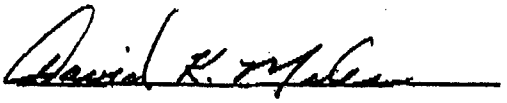
USE OF LOW CLEARANCE SIGN (W12-2)

Low clearance signs (W12-2) should be placed on or at all overpass structures with clearance less than 16'6". The sign shall be a diamond shape minimum 36" x 36". The preferred sign location is overhead the structure. In lieu of this location the sign may be ground-mounted or placed on the structure column.

An advance low clearance sign should be used in advance of all structures with clearance less than 14'0". The advance sign shall consist of the W12-2 sign and a rectangular supplemental plate. The legend of the supplemental plate shall be "XX FT/MI AHEAD". The advance low clearance sign should be placed before the nearest intersecting road or wide point in the road at which a vehicle can detour or turn around.

Advance warning should not normally be done for structures with clearances over 14'0". If there is a special or unique situation, an engineering evaluation should be used for structures over 14'0".

Approved by:
Traffic Engineering Panel
November 2, 1993



David K. Miles, P.E.
Engineer for Traffic and Safety

R-234

Memorandum

UTAH DEPARTMENT OF TRANSPORTATION

DATE: February 10, 1994

TO : DISTRICT DIRECTORS

FROM : Howard H. Richardson, P.E.
Assistant Director

SUBJECT: Clarification on Use of Signs:
"Slower Traffic Keep Right" and
"Slower Traffic Use Flashers"

Apparently some confusion has occurred concerning the subject signing. The following explanation I hope will clarify previous instructions:

"SLOWER TRAFFIC KEEP RIGHT"

This sign is intended to remind motorists not to impede traffic. It is to be used primarily on rural interstate as the fourth sign in the post interchange signing sequence when space permits. This sign should also be used on urban interstate where sign spacing allows. While it is necessary to utilize all traffic lanes in the urban area during peak hours, this signing may have some benefit during non-peak hours. The post interchange signing sequence consists of a Route Marker, a Speed Limit Sign, a Distance Sign, and a Slower Traffic Keep Right Sign. For rural communities that have more than one interchange, the sign should normally be posted only at the last interchange. The sign may be used on other rural primary multi-lane high speed routes at the discretion of the traffic engineer. It is not necessary to use the "Slower Traffic Keep Right" sign on grades in conjunction with the "Slower Traffic Use Flashers" sign, although it may be used at these locations at the discretion of the traffic engineer. The "Slower Traffic Keep Right" sign should not be used on climbing lanes. For climbing lanes the Standard Drawing 745-46 should be followed.

"SLOWER TRAFFIC USE FLASHERS"

This sign is intended to be used on steep grades where a number of vehicles (semi-trucks, R.V.'s, etc.) travel 20 MPH or more below the posted speed limit and the grade is 1/2 mile or more in length. The sign may be posted on any type of highway facility, i.e., interstate, two-lane two-way, climbing lanes, etc. and should be positioned near the beginning of the grade.

During the past 6 months we have had a number of complaints and requests to do something to remind motorists not to impede traffic. This guideline was developed to address the issues by the Traffic Engineering Panel and has the support of the top management. Installation of the necessary signs is to be completed by June 30, 1994.

HHR/cdf

cc: District/Regional Traffic Engineers

AASHTO Bookstore

Part I: Guidelines for the Selections of Supplemental Guide Signs for Traffic Generators Adjacent to Freeways; Part II: Guidelines for Airport Guide Signing; and Part III: List of Control Cities for Use in Guide Signs on Interstate Highways

The guidelines outlined in Part I of this newly revised document are intended to provide a basis for development of individual State policies for the selection of supplemental guide signs for traffic generators adjacent to freeways. These policies should consider local needs, customs and legal requirements. Part II contains the new guidelines for supplemental guide signs for airports. Part III contains the list of approved control cities for purposes of providing directional guidance on the Interstate Highway System.

Publication Code:	GSGLC-4
Year Published:	2001
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Pavement Markings

This Section coming soon!

Traffic Signals

11-300.3 WARRANT 11 CRITERIA

Signal Warrant #11 (Peak Hour Volume) shall not be applied unless all other reasonably appropriate remedial engineering measures have been installed such as:

1) Removal of sight distance obstructions.

2) Parking prohibitions.

3) Warning and regulatory signs.

4) Right-and left turn lanes.

5) Channelization.

6) Pavement markings.

7) Illumination and delineation.

8) Curbs and gutters.

9) Driveway Elimination.

10) Sidewalks.

11) Turn prohibitions.

12) Pedestrian rerouting.

13) Acceleration lanes.

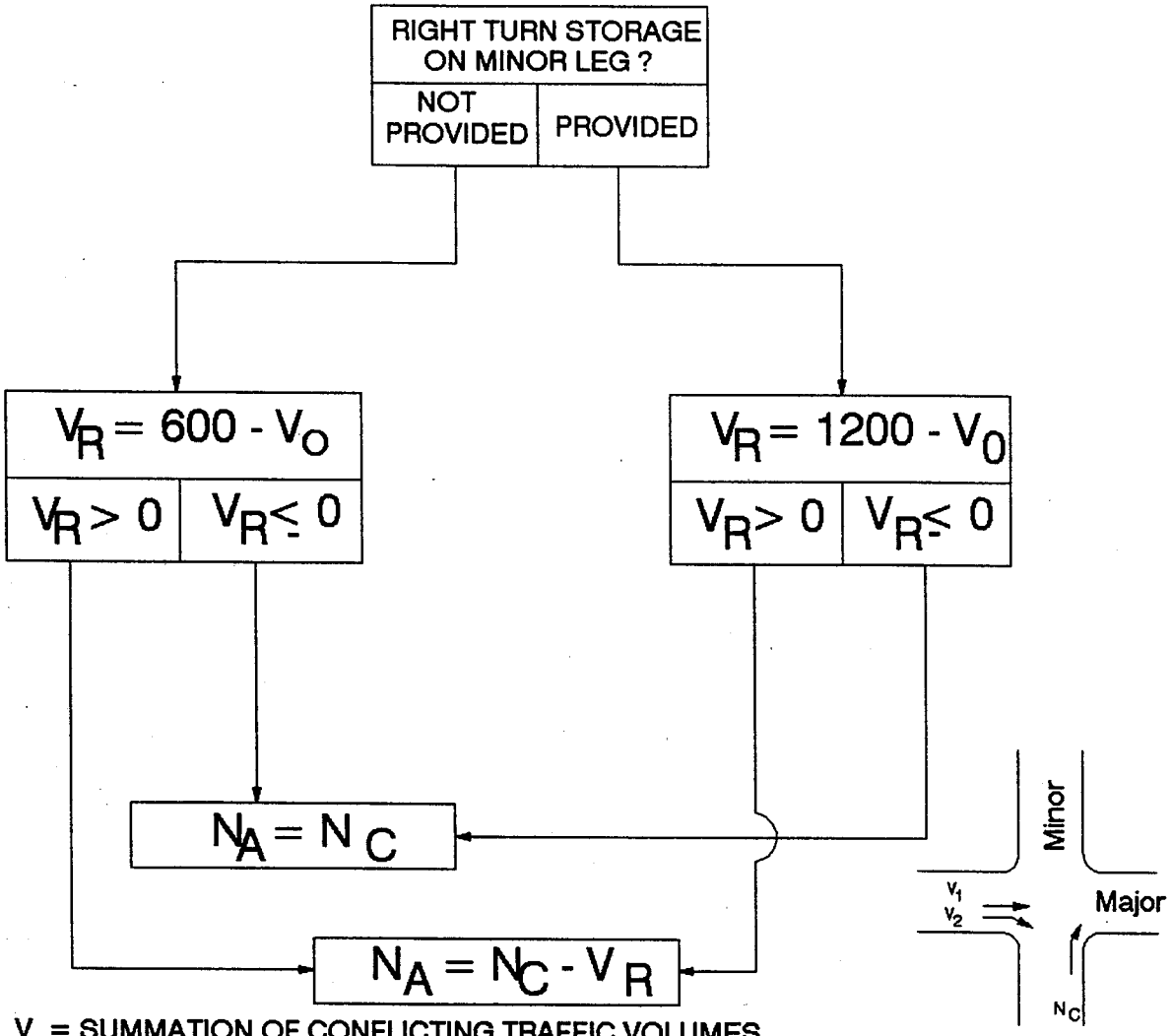
14) Pavement overlays.

15) Police direction.

16) Staggered shifts.

RIGHT TURNS TO BE INCLUDED IN SIGNAL WARRANT

REVISED (MAY 94)



V_0= SUMMATION OF CONFLICTING TRAFFIC VOLUMES.

$$V_0 = 1/2\, V_2 + V_1$$

V_2= 0 , IF RIGHT TURN POCKET IS PROVIDED ON THE MAJOR LEG

V_1= THRU TRAFFIC IN THE OUTER LANE.

WHEN SEPARATE MAJOR STREET MOVEMENT DATA ARE NOT AVAILABLE, USE:

FOR ONE SHARED LANE, V_1 = COMBINED THRU & LEFT VOLUMES.

FOR TWO LANES USE V_1 = 60 % OF TOTAL COMBINED THRU & LEFT VOLUMES.

FOR THREE LANES USE V_1 = 40 % OF TOTAL COMBINED THRU & LEFT VOLUMES.

MULTIPLE LANE REDUCTIONS APPLY TO THRU LANES ON MAJOR LEG

V_R= RIGHT TURNS ALLOWED THROUGH GAPS

N_C= ACTUAL NUMBER OF RIGHT TURNS

N_A= NUMBER OF RIGHTS TO BE INCLUDED IN WARRANT

NOTE: PEDESTRIAN VOLUMES SHOULD BE CONSIDERED IN ACCORDANCE WITH THE HIGHWAY CAPACITY MANUAL

GUIDELINES FOR FREE RIGHT TURNS

OBJECTIVE: To determine need for free right turn at any intersection. Factors that should be considered in the design of a free right turn.

SCOPE: For capacity or safety reasons a free right turn movement may be provided at any intersection. (signalized or non-signalized)

PROCEDURE: Field Information Required:

Volume counts - Peak hour directional count
Truck Percentages
Geometrics of Intersection
Any Access Locations
Location of any Obstruction

Capacity Analysis should be conducted to determine need for free right turn movement.

Merge length should be determined using AASHTO values. Determine if access fall within the merge distance.

Consider impact of any access opening that falls within the merge distance.

1) Type of traffic using access.
2) Traffic demand at access.
3) Separate weave analysis may need to be conducted for this condition.

Consider any obstruction that would impact widening for auxiliary lane (all free right turn movements require acceleration and merge distance plus 300 foot merge tapers).

Review accident history to identify any geometric problems that may exist.

Consider impact on pedestrian traffic - this may require a separate traffic signal to provide gaps and improve safety for pedestrians.

Design of free right turn should consider the following:

1) Placement of traffic control devices (signal poles, signs, etc.)
2) Pedestrian handicap ramps and crosswalks.
3) Type of vehicles - heavy demand of large trucks may require wider shoulders to allow for off-tracking.

Memorandum UTAH DEPARTMENT OF TRANSPORTATION

November 15, 1994

To: Traffic Engineering Panel

From: David Kinnecom

Re: Timing of Yellow Interval at Traffic Signals

As requested, I contacted Departments of Transportation in adjacent states to determine their practice in timing yellow intervals at traffic signals. The results of this survey are summarized below.

State	Contact Person	Range of Yellow	Vary By Speed	Comments
Nevada	Bill Christopherson 702-687-5406	3-5 Secs	YES	Adv. warning high speeds
Colorado	Chris Lilly 303-757-9950	4 secs art 3 secs minor	NO	AR up to 2 secs
Arizona	Brent Headley 602-255-6612	3-5 secs	YES	AR based on width
Idaho	Greg Laragan 208-334-8558	4 secs	NO	New policy for low speed
Wyoming	Jerry Downs 307-777-4171	3-5 secs	YES	Complex formulas

There are two different theories about timing of yellow.

The first is that the length of the yellow interval should be the same at all intersections, regardless of the approach speed. Colorado and Idaho follow this practice, and use a constant 4 seconds. The theory is that when drivers see a yellow indication, they know exactly how long the yellow will be, and make their decision accordingly whether to stop or continue through the intersection.

The other theory is that the yellow should be varied according to the approach speed of the vehicles. On low speed approaches or left turns, a shorter yellow makes the intersection more efficient. At high speeds, a longer yellow provides more safety for vehicles in the dilemma zone. Arizona, Nevada, and Wyoming follow this practice.

According to Bob Gibby, UDOT used to follow the first method (constant yellow) up until about 5 years ago. One reason for this was that some older controllers did not provide reliable and precise timing. For safety, controllers at all intersections were set at 4 seconds, which is overly conservative in some cases.

In recent years, UDOT has been trying to set yellow timing in accordance with approach speed. On reason for this is greater number of signals on high speed roads (e.g. Bangerter Highway, US 89 in the Layton area). At low speed congested intersections, shorter yellows have been used to increase capacity. However, we still have many older intersections with the 4 seconds yellow time, that is not based on approach speed.

In summary, there does not appear to be any one clear cut difference between yellow timing in Utah and adjacent states. Many of our older signals are timed with a constant yellow similar to those in Colorado and Idaho. Our current practice on new signals is to engineer yellow timing using a method similar to that of Arizona, Wyoming, and Nevada.

On the whole, it does not appear that differences in yellow times would be great enough to affect driver behavior.

Design of Signalized Intersections:

Guideline and Checklist

Prepared by:
Utah Department of Transportation

Division of Traffic & Safety
Signal and Lighting Design

Updated: 3/1/04

TABLE OF CONTENTS

SYMBOL LEGEND

Denotes an important piece of information, idea, or concept.

Denotes a new procedure, idea, or concept.

1.0 GENERAL

This guideline is given as a general instruction primer and is intended to supplement good judgment, engineering design, and common sense. It must never be used as a substitute for them.

Each intersection has unique characteristics that must be considered for appropriate signal design. When designing a traffic signal always include a site visit during the scoping/kickoff meeting to determine the design parameters and a second visit during the design process to check the design. Make note of grade considerations both on the road and behind curb & gutter (where the pole will be located). Try to avoid conflicts with existing utilities including overhead lines. Drainage is always an issue at intersections. For safety and roadway efficiency provide for the removal of any drainage water so a minimum of 20 mph speed can be maintained through the intersection. Remember you are designing (describing) a three-dimensional product in a two-dimensional plan set.

All intersections should be designed as fully actuated. The Utah Department of Transportation utilizes fully actuated signal systems through the implementation of in-pavement detector loops or video detection.

The proposed intersection should be designed to meet a Level of Service (LOS) “D” or better based on 20-year projected traffic volumes. Intersection LOS analysis may be facilitated by using computer programs such as: SIG/CINEMA; SYNCHRO; TRANSYT-7F; or PASSER II.

Develop a signal timing plan for each signal location based on existing traffic volumes. The signal timing plan should be included on the Signal Plans and is used for the initial field setup of the signal controller.

The Division of Traffic & Safety warrants traffic signals throughout the State. Signal Warrant documentation includes a warrant memo with the current directional volume counts including peak hour volumes, warrant analysis, and an Operational Safety Report (OSR). This information is available upon request (refer to the contact list at the end of the guidelines).

2.0 GENERAL PLAN INSTRUCTIONS

The following are general instructions to be used as a guideline in laying out the plan sheets. The signal sheets are to be in 1”=20’, or at a common scale that best suits the intersection. CADD system 11”x17" reduced plan sheets will be plotted at 1”=40’ scale.

2.1 TITLE BLOCK

The four lines in the title block contain the following information:

The **first and second line** of each title identifies the Project Name.

The **second line** of each title block identifies the location, and includes the address and city.

The **third line** of each title block identifies what information the sheet contains.

Example: SIGNAL PLAN
SUMMARY SHEET
DETAIL SHEET

The **fourth line** is for the project number.

Include the following individual design sheets for every signal location in the project:

Topo-R/W-Utilities
Plan Sheet — Identify the Topo, Utilities, Right of Way and display the signal poles. Check overhead clearance for mast arms and lighting extensions. **NOTE:** The size and type of utilities should be listed, not just "Gas Line" but "6 inch High-Pressure Gas Line".

Striping and Signing
Plan Sheet — Include all pavement striping, pedestrian access ramp locations and signing.

Traffic Signal Plan
Plan Sheet — Describe the traffic signal design. Include the length of the mast arms, the location of the traffic and pedestrian signal heads in relation to the lane lines. Identify light pole or luminaire placement, detector loops or video camera placement, and phasing diagram. Show utilities that may conflict with pole placement.

NOTE: Intersections where there is no possibility of an opposing left turn, ("T" intersection) lagging left-turn phasing may be preferred. A separate sheet may be required for the phasing diagram.

Detector Circuit
Plan Sheet — Describe the layout of the detector loops or video cameras, junction boxes, number and sizes of conduits, and the number and routing of the home runs.

Signal Circuit
Plan Sheet — Describe the layout of the junction boxes, the number of and size of conduit, lighting, power source and signal circuit cables, and future use conduit, if applicable. This may require more than one sheet.

Interconnect
Plan Sheet — Describe the interconnect layout and details. This sheet follows the numbering of the last intersection, if applicable.

2.2 PLAN SHEET NUMBERING

Sheet numbering includes a letter code that identifies the type of sheet. The appropriate code letter is placed before the consecutive sheet numbering, e.g., RD-1, RD-2, RD-3, etc. Include only codes applicable to the signal project and eliminate all others that are not needed.

Sheet 1's (e.g. title sheet, 1A-plan sheet codes and descriptions, 1B-index to plan sheets, 1C and 1D-index to standard drawings, 1E-storm water pollution prevention plan, etc.) Do not require a sheet identification code.

ID CODE LETTER	SHEET NAME
1	Title Sheet
1A	Plan Sheet Codes and Descriptions
1B	Index to Plan
1C-1D	Index to Standard Drawings
1E	Storm Water Pollution Prevention Plan
TS	Typical Sections
DT	Details - which may include minor structures if no structure number is required.
SM	Summary - (not for signal summaries)
TC	Traffic Control (Use only when paid for by individual items)
RD	Roadway Plan
RP	Roadway Profile
PP	Plan and Profile - Use for small projects that can combine all information on the same sheet.
UT	Utility/Topography
UR	Utility Relocation
RR	Railroad
GR	Grading
DR	Drainage
IR	Irrigation
EC	Erosion Control
LS	Landscaping
WM	Wetland Mitigation
SS	Signing and Striping
SG	**SIGNAL –** SG-xx for Signal Plan Sheets, SG-Sx... for Signal Summaries. When a project has more than one signal intersection, individual intersections are numbered with a letter at the end, such as: SG-1A thru SG-9A and SG-1B thru SG-9B, etc.
SI	Signal Interconnect
LT	Lighting
AT	Advance Traffic Management System
RW	Right of Way
MS	Material Site
—	Structures Drawings
—	Standard Drawings

2.3 NORTH ARROW

When signalized intersections are included as part of a roadway project, orient the north arrow in the same direction as the intersection on the roadway plans. For individual signal projects orient the north arrow towards the top of the sheet. Refer to the latest version of the UDOT CADD Standards for the proper cells.

3.0 TRAFFIC SIGNAL DESIGN

3.1 SIGNAL POLES

Pole Numbering – The pole numbering starts with the pole in the upper left-hand corner as number P1, and continues clock-wise around the intersection.

Placement – Signal poles should be located as close to the center and back of the corner and pedestrian ramps as possible, considering the underground and overhead utilities. Push buttons must be no greater than 10’ from pedestrian ramp TBC line. A supplemental pedestrian pole may be required.

Overhead clearance is very important where 30-foot or 40-foot luminaire extensions are used. Maintain minimum clearance from primary conductors to luminaire. Contact Utah Power for required safe working clearances. We now have the option of using a vertical luminaire extension that may help in avoiding these conflicts.

When dual mast arms are used, the length of arm is limited to 45 ft. for each arm to avoid overloading the foundation.

NOTE: A specific signal pole is required for two different ranges of mast arm length. The bolt circle at the mast arm connection in each range is the same. A special pin welded to the 50’ to 75’ arms prevents the accidental installation of a long arm on the dual mast arm signal pole. The two ranges are as follows:

- 25 ft. to 65 ft. mast arms
- 70 ft. and 75 ft. mast arms

NOTE: All signal poles now require the same 23- inch anchor bolt circle. Refer to Standard Drawing SL-4 for the detail.

3.2 SIGNAL HEADS

Proper placement of signal heads over the roadway dictates the length of mast arm used and to some extent the location of the pole foundation. The standard mast arm length is 25 ft. to 65 ft. (available in five-foot increments). For wide roadways or special circumstances a 70 ft. or 75 ft. mast arm may be specified.

NOTE: A supplemental near-side signal face is required for signal heads located more than 150 ft. from the stop bar. **Signal Head Placement:**

- Apply good engineering judgment when determining signal head placement.
- Provide at least two signal heads for the major movement.
- Place the signal heads no closer than 8 ft. apart. Refer to Standard Drawing SL 1A and SL 1B for standard head mounting locations.
- Do not locate the right most signal head over the shoulder or a curb line.
- Use signal head bracket mounts to mast arm per Standard Drawing SL 2.
- Provide 17'-6" clearance from bottom of signal head or back plate to roadway surface.

Through Movement Signal Heads:

- Place the left most through signal head 3 feet to the right of the dividing line between opposing traffic as you look across the intersection.

Left-Turn Signal Heads:

- **Exclusive/Permissive Left** – Place the signal head regulating the left-turn movement 3 ft. to the right of the dividing line between opposing traffic as you look across the intersection.
- **Single Dedicated Left –** Place the signal head regulating the left-turn movement over the center of the opposing left-turn lane.
- **Dual Left** – Place the signal head regulating the left-turn movement between the two left-turn lanes. Specify a mast arm mounted dual left-turn sign (Modified R3-8).

LED Lenses:
Specify LED lenses for all traffic and pedestrian signal heads. If intersection has relatively new signal equipment that will remain in service, retrofit the existing heads with new LED lenses.

3.3 LEFT-TURN LANES

Width – Provide 12 ft. wide left-turn lanes. If this is not possible discuss the issues with the Region Traffic Engineer. Never exceed 12 ft. for Permissive or Exclusive/Permissive left-turn lanes. Provide a minimum 16 ft. receiving lane width for single left-turn movements (measured from the tangent section of lip of curb & gutter). Provide 30 ft. receiving lane width for dual left-turn movements.

Alignment – Align the left-turn lanes through an intersection to enable the driver to see past the vehicle in the opposing left-turn lane. **Left-turn lanes should not encroach on through lane alignment.**

Length – Design the length of the left-turn lane to accommodate the queue volume without backing traffic into the through lane. Design raised island storage to be as long as practical to not affect the efficiency of the through movement.

3.4 TRAFFIC DETECTOR LOOPS

The detector loop is the sensing element of the detection system. It is formed by wrapping multiple turns of single conductor stranded wire in PVC Conduit (trenched), or a saw slot around the loop perimeter. This area of the traffic lane becomes the detected zone.

The **lead-in** is the continuous wiring between the loop in the street and the junction/splice box.

This wire is splice free from start to finish and is the same single conductor wire that makes up the loop. Extended to the edge of the road for hook-up.

To reduce noise pick-up and the formation of stray electrical fields that may produce unwanted detection points the lead-in wires must be twisted about themselves. For saw-cut installations 1 twist per foot is required. For PVC conduit installations provide at least 3 twists per foot.

NOTE: Regardless of how lines are drawn on plans, each loop and lead-in shall be contained in its individual and separate PVC conduit to the junction box.

The **home run** is that portion of the detection system that connects the detector loops in the street (which have been run to the junction box on the side) to the controller cabinet. Twisted pair, two-conductor shielded wire is used. Each detector group shall have a separate homerun cable and amplifier channel in the traffic signal cabinet. The junction box loop wire connections are **the only traffic signal field wire splices allowed.**

Detector Type	Loop Size
Lane Detectors	6 ft. x 6 ft.
Q-Loops	6 ft. x 12 ft.
Dilemma Zone	6 ft. x 6 ft.

NOTE: Lane widths less than 10 ft. require additional consideration to reduce the loop size or placement to avoid interference with adjacent lanes. Never use a detector loop smaller than 4.5 ft. wide.

Placement – Please see Figures 1-5 below for a detailed description of the recommended detector placements for each approach of the intersection. The detector placements are based on the 85th percentile approach speed to the intersection (as opposed to the posted speed limit). The Figures take into account the dilemma zones for the approach.

Figure 1 – Vehicle Detector Placement for Low Speed Intersection Approach (35 MPH or less)
Figure 2 – Vehicle Detector Placement for Moderate Speed Intersection Approach (40 MPH)
Figure 3 – Vehicle Detector Placement for Moderate to High-Speed Intersection Approach (45-50 MPH)
Figure 4 – Vehicle Detector Placement for High-Speed Intersection Approach (55-70 MPH)
Figure 5 – Vehicle Detector Placement for Left & Right Turn Intersection Approach

The detector locations on the detector placement figures are measured from the stop bar edge closest to the detectors to the beginning of the loop detector. Pay special attention to the notes listed on each of the figures, since they will provide valuable information in respect to the specific detector diagram for the figure.

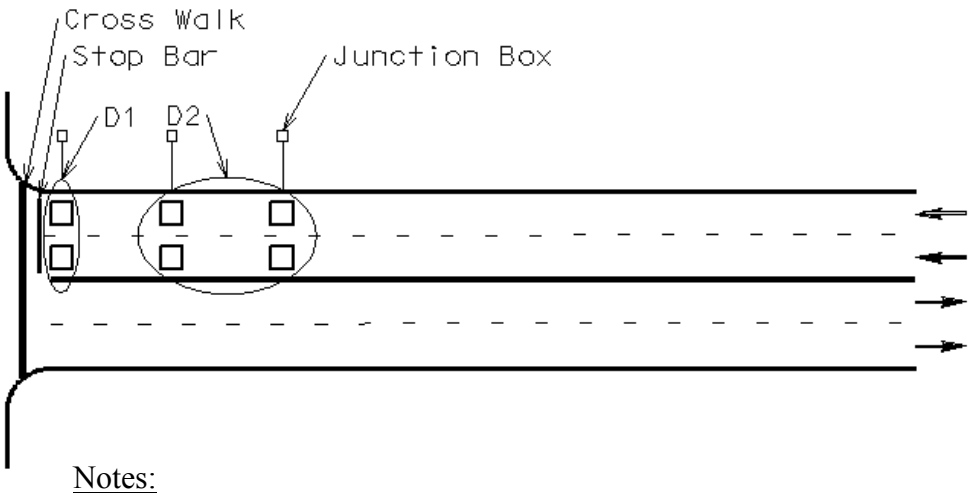
Pay special attention to intersections with non-standard geometrics. Place loops so they operate in the "non-lock" mode. Apply good engineering judgment for additional loops as needed where vehicles may be prone to stop ahead of the stop bar.

If circular loops are used for queue loops, then two loops may be placed 3 ft. apart to constitute a queue loop. Consider using pre-formed loops for rotomill and overlay projects.

Design stop bar and pedestrian crossing lines to be generally parallel to the associated roadway. When the angle between the intersecting streets is not perpendicular specify stop bar loops that are parallel to the stop bar. This stop bar detector loop may become a parallelogram in order to remain parallel with both the lane and the stop bar. The other detector loops (non-stop-bar) remain square to the through lane pavement markings.

If a detector loop location is in conflict with a manhole, water valve, etc., adjust the loop placement forward or backward in the shortest direction from the optimum position.

Figure 1 – Vehicle Detector Placement for Low Speed Intersection Approach (35 MPH or LESS)



Notes:

1. Each detector group shall have a separate homerun cable and amplifier channel.

2. No more than 4 detector loops shall be hooked up to the same homerun cable or amplifier channel on a minor street & no more than 6 loops on an arterial street.

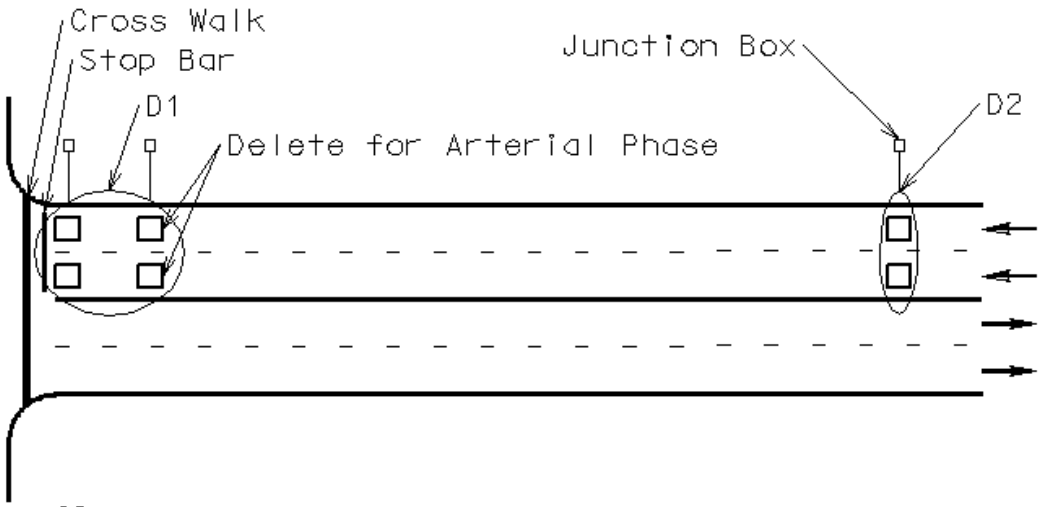
3. All detectors in group D1 should be spliced in series on the same homerun in the junction boxes.

DETECTOR FUNCTIONS:
A = Normal or Standard

SPEED (MPH)	LOCATION				DETECTOR GROUP #	DETECTOR FUNCTION	INDUCTANCE LOOP SIZE
	D1	D2					
25	3'	34'	65'		D1	A	6' x 6'
30	3'	39'	75'		D2	A	6' x 6'
35	3'	44'	85'				

Location = distance from stop bar edge closest to detectors to beginning of detector

Figure 2 – Vehicle Detector Placement for Moderate Speed Intersection Approach (40 MPH)



Notes:

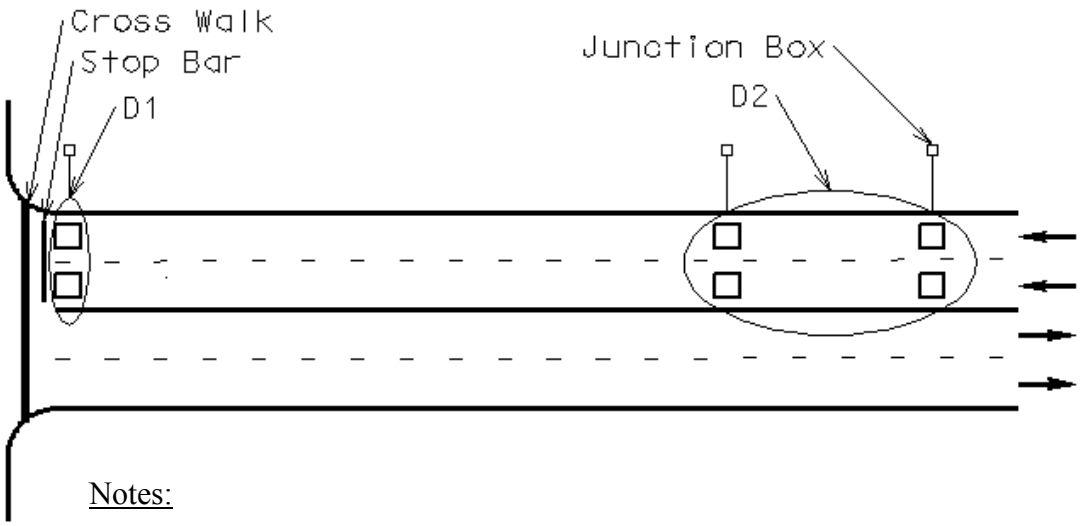
1. Each detector group shall have a separate homerun cable and amplifier channel.
2. The rear detectors for detector group D2 may be omitted if the phase is an arterial on vehicle recall.
3. No more than 4 detector loops shall be hooked up to the same homerun cable or amplifier channel on a minor street & no more than 6 loops on an arterial street.
4. All detectors in group D2 should be spliced in series on the same homerun in the junction boxes.

DETECTOR FUNCTIONS:
A = Normal or Standard
B = Stop Bar with Extend Timer Reset

SPEED (MPH)	LOCATION			DETECTOR GROUP #	DETECTOR FUNCTION	INDUCTANCE LOOP SIZE
	D1		D2			
40	3'	24'	250'	D1	B	6' x 6'
				D2	A	6' x 6'

Location = distance from stop bar edge closest to detectors to beginning of detector

Figure 3 – Vehicle Detector Placement for Moderate to High-Speed Intersection Approach (45-50 MPH)



Notes:

1. Each detector group shall have a separate homerun cable and amplifier channel.

3. No more than 4 detector loops shall be hooked up to the same homerun cable or amplifier channel on a minor street & no more than 6 loops on an arterial street.

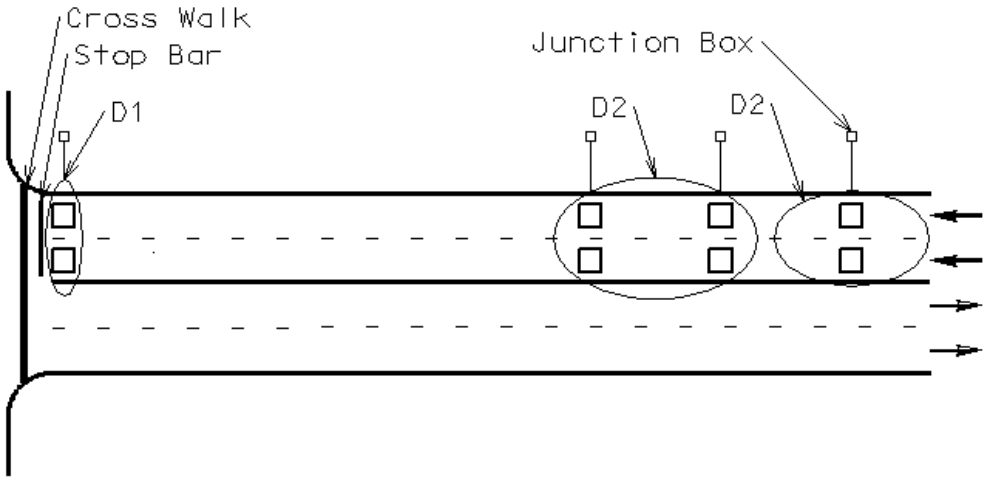
3. All detectors in group D1 should be spliced in series on the same homerun in the junction boxes.

DETECTOR FUNCTIONS:
A = Normal or Standard
B = Stop Bar with Extend Timer Reset

SPEED (MPH)	LOCATION			DETECTOR GROUP #	DETECTOR FUNCTION	INDUCTANCE LOOP SIZE
	D1	D2				
45	3'	200'	300'	D1	B	6' x 6'
50	3'	230'	350'	D2	A	6' x 6'

Location = distance from stop bar edge closest to detectors to beginning of detectors

Figure 4 – Vehicle Detector Placement for High-Speed Intersection Approach (55-70 MPH)



Notes:

1. Each detector group shall have a separate homerun cable and amplifier channel.

4. No more than 4 detector loops shall be hooked up to the same homerun cable or amplifier channel on a minor street & no more than 6 loops on an arterial street.

3. All detectors in group D1 should be spliced in series on the same homerun in the junction boxes.

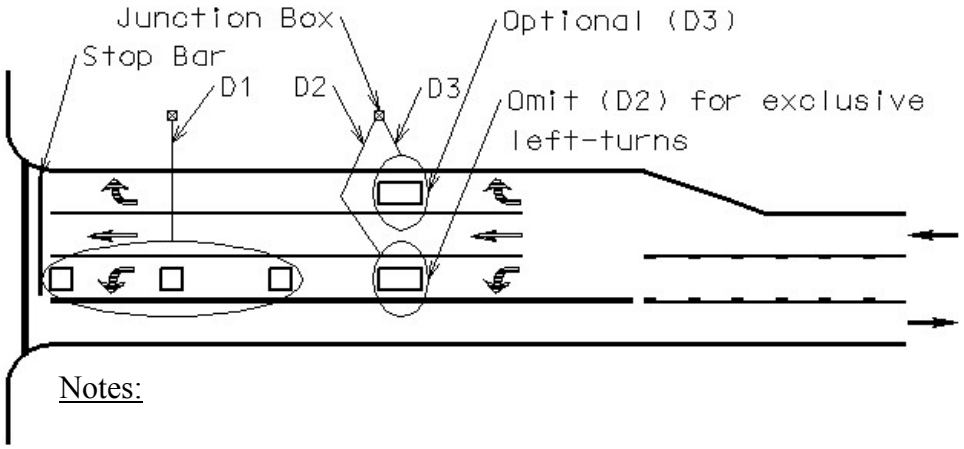
DETECTOR FUNCTIONS:
A = Normal or Standard
B = Stop Bar with Extend Timer Reset

SPEED (MPH)	LOCATION			
	D1	D2		
55	3'	140'	270'	400'
60	3'	195'	335'	475'
65	3'	240'	395'	550'
70	3'	295'	460'	625'

DETECTOR GROUP #	DETECTOR FUNCTION	INDUCTANCE LOOP SIZE
D1	B	6' x 6'
D2	A	6' x 6'

Location = distance from stop bar edge closest to detectors to beginning of detector

Figure 5 – Vehicle Detector Placement for Left & Right Turn Intersection Approach



Notes:

1. Each detector group shall have a separate homerun cable and amplifier channel.

2. No more than 4 detector loops shall be hooked up to the same homerun cable or amplifier channel.

3. Omit the queue detector (D2) for protected-only left turns.

4. For double left turn lanes, group the back 4 detectors separate from the front 2 detectors.

5. Queue Detectors (D2 & D3) should have a 2-3 second delay.

6. Queue Detector (D3) for the right-turn lane should generally be omitted, except in
any of the following situations:

a. The right-turn is the critical lane group for the phase.
b. There are sight distance restrictions making a right-turn-on-red difficult.
c. There are significant times of the day with insufficient gaps in merging traffic.

LOCATION				
D1			D2	D3
3'	19'	35'	51'	51'

DETECTOR FUNCTIONS:
A = Normal or Standard

DETECTOR GROUP #	DETECTOR FUNCTION	INDUCTANCE LOOP SIZE
D1	A	6' x 6'
D2	C	6' x 12'
D3	C	6' x 12'

C = Extend/Delay

Location = distance from stop bar edge closest to detectors to beginning of detector

Conductors:
All loops 6 ft. x 12 ft. and smaller consist of four turns of single conductor No. 14 AWG wire. **No twists are allowed in the loop itself.**

Saw-cut Loop Installations:
Single conductor No. 14, stranded, polyethylene/nylon insulated wire, enclosed in a loose fitting polyethylene duct (IMSA 51-5). Twist the lead-in from the loop to the junction box at least 1 turn per foot (extra saw cut width is required to accommodate the twisted wire).

PVC Conduit Loop Installations:
Single conductor No. 14, stranded cross-linked polyethylene insulation type XHHW, IMSA Spec. 51-3 wire. Twist at least 3 turns per foot in the lead-in, from the loop to the pull box.

Home Runs:
Two conductor No. 14 twisted pair cable running from the detector loop splice/junction box to the controller (Spec. IMSA 50-2).

Additional Detector Loop Design Criteria:

- Intersections that involve the installation of new asphalt or concrete paving provide an opportunity to place detector loops beneath the pavement, in the top layer of road base. Detectors needed for future use, both number and placement, should be considered while the opportunity is there for them to be placed under the new pavement.

- Install queue-loops when the 5-year traffic projections indicate left-turn phasing will be warranted. Left turn signal heads will only be installed when warrants are met.

- Most traffic signal cabinets are ordered with only one detector rack (4 detector amplifiers with up to 4 channels on each amplifier – 16 channels). If more than 16 channels are needed, order the traffic signal cabinet with two detector racks.

- For the new detector design, in order to minimize detector cross talk between detectors on the same approach, it is recommended to group detectors on the same approach to the same detector amplifier. Each detector amplifier has 4 channels. The convention (to the right) should be used for each detector amplifier. (Example: Detectors assigned to phases 2 & 5 should be on the same amplifier.)

Detector Phase Assignment

	Phase Assignment								
Detector	1	2	3	4	5	6	7	8	
1					X				Detector Amp #1
2		X							
3		X							
4		X							
5	X								Detector Amp #2
6						X			
7						X			
8						X			
9							X		Detector Amp #3
10				X					
11				X					
12				X					
13			X						Detector Amp #4
14								X	
15								X	
16								X	

WB / EB / SB / NB / WB / EB / SB / NB

Loop Installation Methods:

Saw Cut Installation – Use when concrete surface exists or where newer asphalt surface exists that shouldn't be marred by trenching.

Trenching Installation – Use to get the loops below the asphalt surface that tends to move or rut for enhanced durability. Trenching must be used in pavements which are in poor condition or which are likely to receive an overlay of new asphalt. Trenching must be calculated separate from the conduit and conductor since one trench will hold multiple conduit and conductors.

Home Runs from Junction Box to Controller:

The limitation to combining four loops for a home-run on the minor street is to assure adequate sensitivity to detect motorcycles. This traffic movement is not intended to be served in every cycle and will be skipped when no vehicles are sensed. Major traffic movements are "recalled" and given the green signal in all cycles. Detection missing a small vehicle is of little consequence on a recalled phase. Missing these vehicles (not giving a green phase) in a left turn, or a minor cross street, can become very serious.

3.5 RELATING DETECTOR LOOPS TO SIGNAL PHASING

It is important to utilize a standard numbering system that will provide a consistent way of referencing detector loops for the designer, contractor, and technician working in the cabinet.

UDOT has adopted the National Electrical Manufactures Association (NEMA) traffic signal phase conventions. The standard NEMA detector loop numbering associates each detector to its signal phase. Figure 1 illustrates the NEMA assignment and UDOT conventions to be used.

When the **major street runs north and south, phase 2** is assigned to the northbound through traffic and the associated detector loops.

When **east/west is the arterial**, **phase 2** is assigned to the westbound through traffic (all phases are rotated counter-clockwise 90 Degrees).

When **both roads are major highways**, phase 2 is assigned to the northbound traffic.

- Through phases are numbered clockwise with even numbers.
- Left-turn phases are numbered clockwise with odd numbers, starting with the movement that is opposite phase two.

When dedicated left-turn phases are used the NEMA phase preceding each through movement is used for the left turn (leading-left-turns). For example, Phase 1 will be assigned to the left-turn movement opposing phase 2.

The detector loop schedule indicates the assigned home-run cable and grouping assignment for each loop in the "remarks" column.

Detector Loop Numbering:

Syntax to be used: **(P)(U)(n)(z)**.

P = NEMA phase number
U = loop use (alphabetic)
n = number for the loop in that group
z = home run group alphabetical identification

Loop Use (U)

T = Through / (Right)
L = Left movement
D = Dilemma zone
Q = Queue detectors, left, right or backed-up through
S = System Loops

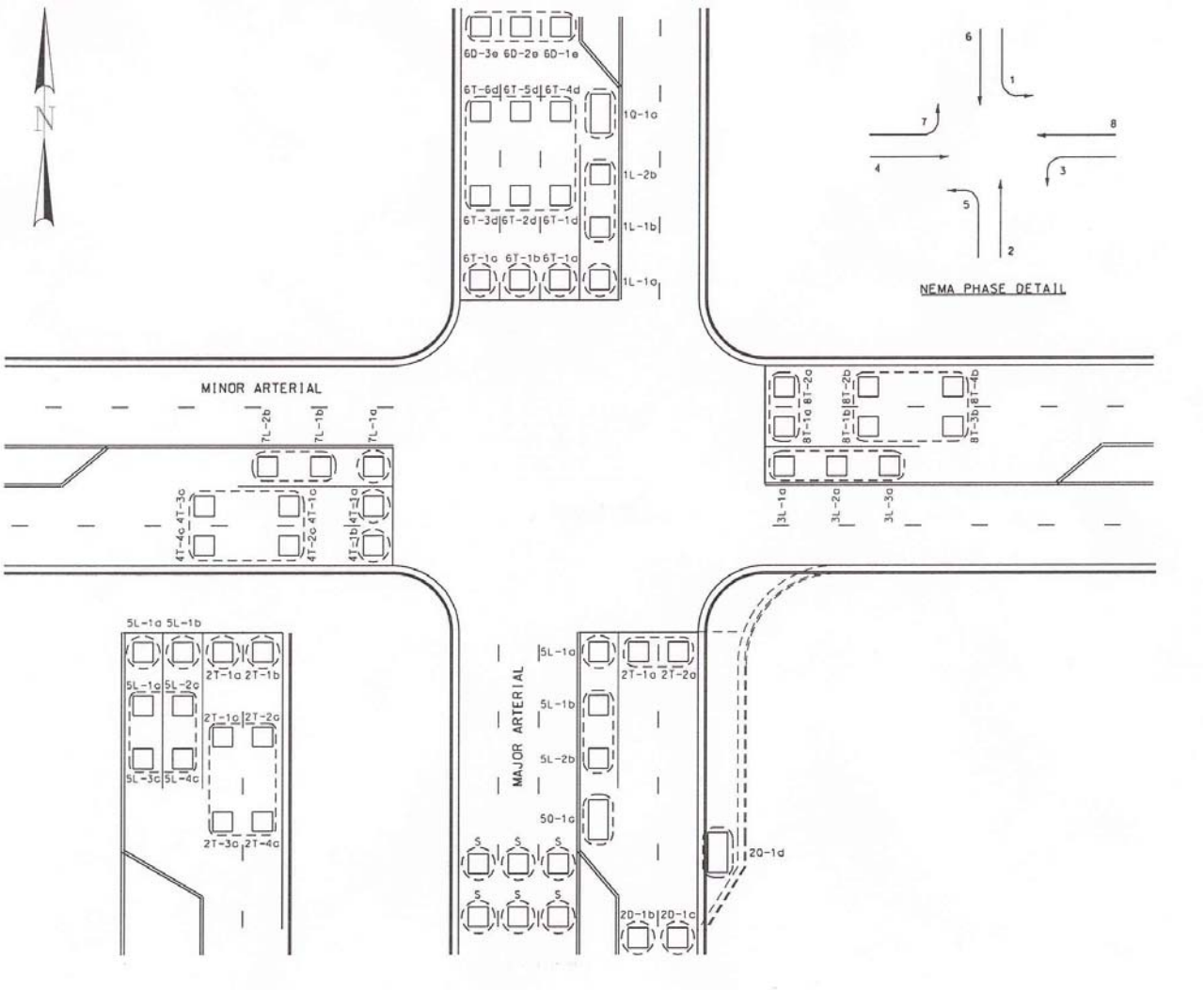
For example, assuming a separate home run for the front loop(s):

Phase 1, front loop would be 1L1a
Phase 1, second loop back would be 1L1b
Phase 1, third loop back would be 1L2b
Phase 1, Queue loop, would be 1Q1c

Numbering starts at the stop bar, nearest the centerline, ascending toward the curb and increasing in value away from the intersection for each phase of the leg. The first loop of a group takes number 1 (one) and the Home Run Alpha Designation (a,b,c,...) for the group it is in. The Left-turn and Through movements for each leg will have an "a" home run.

Assign the System Loops ("S" prefix) in numerical sequence. The designer may include additional characters that further designate system detector loop options.

3.6 NEMA PHASE DETAIL



3.7 LUMINAIRE EXTENSIONS

Place signal pole luminaire extensions at opposite corners over the major roadway 90 degrees from the mast arm unless there is a conflict with overhead utilities. Typically two luminaires are specified per intersection. Large or remote intersections may require up to four luminaries. Specify the following:

- Use 15' luminaire arm length if possible. 10' luminaire arm is also available.
- Use High-Pressure Sodium (HPS) lamps, 250 Watt or 400 Watt.
- Use Full Cut-off Luminaires with Type III distribution, 240 Volt single-phase.

Consider the lamp wattage specified based on the intersection location circumstances. Balance illumination needs with the surrounding environment. If the highway lighting is provided along the corridor, provide 50% greater illumination at the intersection. Refer to the UDOT lighting guidelines and RP-08 for additional information.

Intersections with **video detection** require four luminaires to provide adequate illumination for the cameras. Refer to the Video Detection Section of the Guideline.

3.8 LANE LINES AND INTERSECTION STRIPING

Lane Striping
Show lane striping for the intersection and clearly identify the dimensions and distances required for proper installation. Also indicate the material to be used (tape or paint). Call out any striping removals to avoid motorist confusion once the intersection is opened up to traffic. Show existing striping in a gray scale on the plan sheets.

Pavement Markings
Match existing pavement striping materials. If existing tape is used through the intersection, then replace the markings with tape. Please be aware of this during the design process and specify the material in the design plans.

4.0 CIRCUIT DESIGN

4.1 SIGNAL CIRCUITS

Power Source:
The designer should contact the Region Utility Engineer to request a Work Order from the local power utility and arrange for the power connection. Typically a meeting is scheduled in the field at the signal location. The power source can be from an underground service pedestal, a pole mounted and meter/disconnect service, or a transformer. Refer to Standard Drawings SL 3 and SL 6.

Specify an underground service pedestal if: 1) the local Utility Company requires it; 2) the pole mounted meter/disconnect is not easily accessible or easily located; or 3) the distance is greater than 150 ft. from the controller and is not easily visible.

Use the proper wire size determined from voltage drop calculations made for the intersection.

The calculation includes both the distance from the service to the controller, and back to the service. Minimum acceptable wire size for UDOT projects is No. 6 AWG cable.

Provide three single conductor No. 4 AWG copper RHH-USE-RHW, plus a ground wire from the power source to the underground service pedestal. Use two single conductor No. 6 AWG copper RHH-USE-RHW, plus a bare copper ground wire from the underground service pedestal to the controller cabinet. Black wire is to be used for the "Hot Wire" and White for the "Neutral Wire."

Traffic Signal Heads
7-Conductor No. 14 AWG, Stranded Cable, Spec. IMSA 20-1 (120 volts).

Near side (and other single) Traffic Signal Heads
4-Conductor No. 14 AWG, Stranded Cable, Spec. IMSA 20-1 (120 volts).

Pedestrian Signals
7-Conductor No. 14 AWG, stranded cable, Spec. IMSA 20-1 (120 volts).

Street Lighting
2-Single conductor No. 6 AWG, stranded wires and bare copper ground wire, No. 6 AWG minimum. Larger wire must be used when voltage drop calculations show drops greater than 5% of supply line voltage, Spec. (IMSA 51-1).

Approved waterproof splices may be used in the bases or pull boxes of street lighting circuits. No splicing is allowed elsewhere. Pull-apart molded fuse connectors are required in all light poles (except signal poles with luminaire extensions).

Pedestrian Push Button
4-Conductor No. 14 AWG, stranded cable, Spec. IMSA 20-1 (low voltage).

Signal Detection Home-Run
2-Conductor No. 14 AWG, shielded and stranded twisted pair, Spec. IMSA 50-2 (low voltage). Label each end of home run.

Loop Wire
Saw-cut slot applications, Spec. IMSA 51-7 (low voltage).
Trenched PVC Conduit, Spec. IMSA 51-3 (low voltage).

Video Detection
Power Requirements for all Brands of Hardware:
4-Conductor No. 14 AWG, stranded cable, Spec. IMSA 20-1 (120 volts).

Video Cable Requirements for Peek and Iteris Hardware:
Belden 8281 or equivalent coaxial cable (video), Spec. RG-59. Use for field run < 1000 ft. from pigtail connection at base of signal pole to controller cabinet.

Video Cable Requirements for Trafficon Hardware:
Combined video coaxial/power cable provides splice free connection from camera to controller. State Furnished cable comes in 250 foot, 500 foot, and 1000 foot spools. Specify the

required length when placing State Furnished Material Requisition.

Video Cable Requirements for Econolite Hardware:
6-pair twisted No. 18 AWG, shielded cable Spec. IMSA 60-6 for video signal (low voltage).

Interconnect Cable
No. 19 AWG, 6 pair, Spec. IMSA 60-6 (low voltage).
Fiber optic cable, 6 SMF minimum (refer to contact list regarding interconnect).

4.2 CONDUIT

Use schedule 40 PVC listed electrical conduit for underground signal installation. Use galvanized rigid steel (GRS) listed electrical conduit for above ground applications. Special considerations for Fiber-optic Cable installation are needed (refer to contact list for further details).

Choosing the Right Conduit
The National Electric Code (NEC) requires no more than 40% of a conduit be filled with wire and cable. The cross-section of the wire (single conductor) or cable (multi conductor) varies depending on the type of insulation specified. Listed below are cross-sectional areas for the typical cables used, and the allowable area at 40% capacity for various conduit sizes.

Example: Choose the conduit size required to accommodate 6 detector home runs. The area of a 2-conductor No. 14 cable is selected and multiplied by 6 to obtain a total cable area of 0.831 sq. inches. Therefore the 2-inch PVC conduit is selected as the appropriate size.

Cable Cross-Sectional Area (sq. inches)		40 % of PVC Conduit Area Capacity (sq. inches)	
1-Cond. No. 6	0.1041	3/4 "	0.203
		1 "	0.333
2-Cond. No. 14	0.1385	1 1/4 "	0.581
		1 1/2 "	0.794
3-Cond No. 14	0.1589	2 "	1.316
		2 1/2 "	1.878
4-Cond. No.14	0.1105	3 "	2.907
		3 1/2 "	3.895
7-Cond. No. 14	0.2123	4 "	5.022

Detector Loop Conduit
Use 3/4 inch for lane loops.

Shared Usage

- Traffic signal heads, pedestrian signal heads, and video detection operate at 120 volts and may share conduit.

- Detector loop home runs and pedestrian push button are low voltage circuits and may share the same conduit. Provide separate conduit for video detection cable.

Future Use
Specify two future-use conduits, 2-inches in diameter, placed between all pole junction boxes and the controller cabinet. Place the future-use conduits on top of the other conduits in the trench. Include one continuous No. 14 AWG copper THHN pull wire in each future-use conduit. This wire is used to pull future wire and can also be used to locate the underground conduit run.

Interconnect
Use 1-D conduit to accommodate future fiber optics with Type II-PC junction boxes with 35' of slack at pull locations. Spice locations require Type III-PC junction boxes with 70' of cable slack. Space junction boxes 300 ft. ± intervals. Use large radius sweep bends (3 ft. minimum) for fiber optic cable. Install a locator wire placed in a 1-inch PVC conduit. Refer to Standard Drawing AT 6 and AT 7.

Video Detection
Video power circuit shares the same conduit as the signal power. The video signal circuit shares the same conduit as the pedestrian push button detectors (as noted above). Do not combine video signal in the same conduit used for power. Combined video power/coaxial cable is placed in a dedicated 2" PVC video detection conduit.

4.3 JUNCTION BOXES

Specify only PC (polymer concrete) junction boxes for signal and lighting installations. Place individual, Type II-PC junction box at the base of each signal pole. Always specify a Type II-PC junction box when the Home Runs from more than one leg are being accommodated. The signal pole junction boxes may be eliminated when the cabinet junction Box is near the pole location. Specify a Type III-PC junction box at the controller cabinet.

Shared Usage Power
At the power source junction box the lighting and the signal circuits share the same junction box. From this point (or the underground service pedestal) no other mixing of these circuits is allowed (120 and 240 volts), except inside the signal poles. A separate conduit and junction box is required for 120 volt and 240 volt circuits.

Junction boxes for signal and pedestrian circuits are shared for both power and detection, the conduits however are not shared. These separate circuits are identified on the plans with the appropriate legend.

4.4 POWER SOURCE

Verify the power source in the field with the serving utility company. List the name and phone number of the individual with whom connection will be arranged on the plans. Identify the location of the power source with station and offset and indicate whether it is a pole or ground-mounted transformer.

Coordinate with the local Region regarding agreement requirements with the local municipality for payment of the power for intersection street lighting, connection fees and maintenance. List the contact person's name and phone number on the plans. Remember to contact the UDOT Region Utility Engineer early in the design phase to coordinate the project service needs.

4.5 GROUND RODS

Use 10 ft. x 3/4 inch copper-clad steel UL Listed ground rod shall be installed through the control cabinet foundation in a PVC sleeve. Use a separate UL Listed ground rod, 8 ft. x 5/8 inch in the cabinet junction box driven to a depth so that not more than 6" remains exposed. Both rods are required, even when they are less than 6 ft. apart.

Use 8 ft. x 5/8 inch copper-clad steel UL Listed ground rod installed at each junction box that contains cables with 120 volt circuits or greater. In cases where these boxes are within 6 feet of each other, a single ground rod, located in the lighting box (when available) will suffice provided bonding conductors tie both grounding systems together. Please note the above exception at the controller junction box.

4.6 CONTROLLER AND CABINET

UDOT has adopted the new TS2 technology. Controller cabinets are referred to as "Size 5" and "Size 6". The "Size 5" will replace the old “M” cabinet and "Size 6" will replace the old “P” cabinets.

5.0 OTHER CONSIDERATIONS

Pedestrian Access
Provide pedestrian access in accordance with Standard Drawing GW 5. Include Special Provision 02771M in the construction documents. This Special Provision includes information regarding three material options for detectable warnings (truncated domes), and ramp slope requirements.

5.1 TEMPORARY OPERATION

When modifications are made to an existing signalized intersection, care must be taken to provide for temporary power and signal control where necessary. Phasing of the new construction and demolition of the existing signal conduit and wiring must be given due consideration to insure proper function until it is no longer needed.

When alterations to the existing signal phasing or function or traffic lane assignments are proposed, an approved temporary signal operation/phasing plan is required.

Consider the use of contractor-supplied, temporary, above-ground detectors (video, microwave, radar, etc.) for maintenance of traffic during construction.

5.2 SIGNAL TURN-ON

When turning on a signal for the first time in a newly signalized intersection, consider the following methods to alert the public of this signal going into operation:

- Use a Portable Changeable Message Signs (CMS).
- Place the signal can be put into flashing mode for a short time; the most common

practice is to flash the signal up to 24 hours. This flashing mode should never exceed 72 Hours.

- Notify the local news media.
- Utilize the local law enforcement to draw attention to the change.

5.3 INTERCONNECT

Always consider the relevance of adjacent traffic signal interconnection up to ½ mile spacing. Where feasible, provide for coordination with a 1-D conduit designed to accommodate fiber-optic cable (large radius) installation.

Orient the direction of the 3" conduit stub in the cabinet foundation to accommodate fiber-optic installation. Refer to Standard Drawing SL 10.

5.4 SINGLE POINT URBAN INTERCHANGE (SPUI)

The SPUI has many unique features that need to be addressed in regards to the layout designed (under or over the freeway). When the SPUI is under the freeway the structure height restricts signal head clearance and sign placement. When the SPUI is placed over the freeway the support for signal heads and signing is critical and poor vertical sight distance is an issue. The following recommendations are presented for under and over, single and dual-lane SPUI configurations:

- Off-Ramp Left Turn Movement – Provide advance signals placed on the right side of the island. Place this signal head as far back up the ramp as practicable without confusing the right-turning vehicles. Use circular indications in all sections and do not use programmable heads. Consider using a second advance signal (circular indications) placed on the outer edge of the structure for the under freeway configuration.

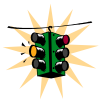
- Left-Turn Signals – Provide circular red and yellow indications, with the green arrows tilted at 45 degrees up from horizontal.

- Left-Turn Movements onto the Freeway – Provide left-turn signs (R3-5) for clarification and lane assignment adjacent to each signal head. Use circular red and yellow with green arrows tilted up at 45 degrees from horizontal. The circular indication is used to give the needed target value in bright sunlight.

Interchange lighting should be placed in the SPUI to ensure the entrances to freeway on-ramps are well lit and visible from the stop bar.

A qualified structural engineer should design the overhead signal bridge structure. Standard tenons are used to mount the signal heads to the signal bridge. Include a detail of the signal bridge and identify the tenon locations to insure proper signal head placement in relation to the traffic lanes. Backer plates for the signal heads will be necessary but may be influenced by the size and height of the support structure.

5.5 VIDEO DETECTION



Video detection has become more reliable in recent years and is now being used as a temporary and permanent replacement for detector loops. Video offers flexibility to both the designer and constructor alike. Good cases for the use of video detection include a new signal or upgrade to an existing signal: after recent paving operations; when roto-milling operations are scheduled in the near future; or during construction phasing operations and ultimately for the permanent installation. Consider Specify video detection only under the approval of the project manager, Region Traffic Engineer, or Division of Traffic and Safety Design Engineer.

Site Survey
Always perform a site survey to check for anything that might block the field of view or impact vehicle tracking such as trees, overhead wires, and commercial light sources.

Camera Placement
Position video cameras on the signal mast arm utilizing 46-inch vertical pole with mounting bracket. The bracket is an astro-brac or equivalent connection to the mast arm and is very stable. .If mounting on the luminaire, the choice between a right-side or a left-side luminaire mount is dependent on the phase sequence used to control the subject approach. For approaches without a left-turn phase, the camera is mounted on the right-side far corner of the intersection. For approaches with a left-turn phase and bay the camera is mounted on the left-side, far corner of the intersection. This location minimizes false calls for service to the left-turn phase. A delay setting should be used for the left-turn detectors to prevent unnecessary calls by departing vehicles. (Only consider the placement on the luminaire under the approval of the project manager or Division of Traffic and Safety). The ideal location of the video camera is placement on the mast arm.

Locate the camera on the mast arm so that it is centered over the opposing left and through lanes. This will ensure good field of view of the vehicles at the stop bar detection zone. A minimum camera height of 20 feet is recommended in recognition of the dirt, spray, and mist that can collect on the camera lens at lower heights. Position the video camera on the mast arm no greater than 25 feet above the road surface so to allow the UDOT region personnel the ability to reach the cameras from their boom trucks.

Video Detection Zones
Video detection should not be used to monitor vehicle presence at distances greater than 250 feet from the video camera. The “rule of thumb” is that you can reliably detect 10 feet for every 1 ft. above the pavement surface the camera is placed, to a maximum distance of around 300 feet (250 feet for 25 ft. heights). For detection distances greater than 250 feet from the video camera, either a separate pole with a video camera will need to be placed upstream of the intersection or loop detection should be used.

The placement of detection zones for video detection should be the same as loop detection for distances between 100 feet from the stop bar up to 250 feet from the video camera. The detection zone length should approximately equal that of an average passenger car.

Stop bar detection zones (within 100 feet from stop bar) will vary depending on the video detection manufacture and intersection geometrics.

If advance detection is used, the stop bar detection zone should have the stop bar with extend timer reset function enabled.

Pay special attention to the passage time (vehicle extension time) when using video detection. Depending on the zone layout at the stop bar, it is not uncommon to use 0.0 seconds. In addition, it may be necessary to use the delay settings. The delay settings are sometimes used to reduce the frequency of unneeded calls. Specifically, a few seconds of delay is often set on the detectors in the stop-line detection zone of each minor-road approach. This setting offers two benefits. First, it eliminates false calls to the minor-road phases by major-road vehicle headlights (such as when a major-road vehicle makes a right turn and its headlights sweep across the minor-road stop-line detection zone). Second, it eliminates false calls to the minor-road phases by tall major-road vehicles.

During the initial video detection setup, the detection zone length should be measured along the roadway with a distance wheel. The most distant upstream edge should be marked with a traffic cone placed on the outside edge of the traveled way.

Luminaires
Place signal pole luminaire extensions at each corner of the intersection to provide good lighting for video detection. Locate the luminaire extension arm perpendicular to the plane of the signal mast arm. This provides good lighting over the detection zone.

- Use 400 Watt luminaires for large intersections in commercial or industrial areas.
- Consider reducing the luminaire wattage to 250 Watt for smaller intersections in commercial or residential areas.
- Use 15 ft. luminaire arms especially when mounting video cameras.
- Refer to the Luminaire Extension Section of the Guideline for details regarding the luminaire.

5.6 MISCELLANEOUS

Please contact the Division of Traffic & Safety if you have any questions regarding this guideline or how it applies to the project that you are working on (refer to Contact List in the appendix). We encourage the designer to contact us early in the design process to discuss standard UDOT intersection design and specific issues regarding your project. Early interaction expedites the design process and helps lead to the successful completion of the project.

APPENDIX

A.1 STANDARD SIGNAL REFERENCE

Mast Arm Lengths (available in five-foot increments):

30’ through 55’ one-piece, curved mast arm
60’ through 65’ two-piece, curved mast arm
70’ and 75’ two piece, straight mast arm

Light Pole Extensions:

Mounting Height:	30' and 40'
Arm Length:	10' and 15’

Mast Arm Mounted Signs:

R10-12, R10-11a	24" x 30"
R3-8	30" x 30"
Street Name Signs	60”, 72”, or 84" x 16"

Anchor Bolt with Hardware (four required per pole)

Signal Poles	2-inch diameter bolts
45’ CCTV Poles	1.5-inch diameter bolts
40’ Highway Luminaire Pole	1-inch diameter bolts

Ground Rods:

Junction boxes	8 ft. x 5/8 inch
Signal controller cabinet	10 ft. x 3/4 inch

Other Reference Materials:

- UDOT Standard Drawings and Specifications, Latest Edition.
- Millennium Edition of the MUTCD, 2000, FHWA.
- A Policy on Geometric Design of Highways and Streets, 2001, AASHTO.
- Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 4th Edition, 2001, AASHTO.
- Manual of Traffic Signal Design, Second Edition, ITE.
- National Electric Code, 2002, NFPA
- An Informational Guide for Roadway Lighting, 1984, AASHTO.
- Roadway Lighting, IESNA, RP-08, 2000.
- UDOT CADD Standards, Latest Edition.
- UDOT Design of Highway Lighting: Guideline and Checklist, Latest Edition.

A.2 CONTACT LIST

DIVISION OF TRAFFIC AND SAFETY

Traffic and Safety Design Engineer	Larry Montoya	(801) 965-4924
Signal & Lighting Engineer	Vacant	N/A
Traffic Studies	Peter Jager	(801) 965-4264
Traffic Operations	John Leonard	(801) 965-4045

REGION TRAFFIC ENGINEERS

Region One	Darin Duersch	(801) 620-1607
Region Two South Area	Ritchie Taylor	(801) 887-3717
Region Two North Area	Chris Siavrakis	(801) 887-3792
Region Two Signals	Deryl Mayhew	(801) 887-3605
Region Three	Doug Bassett	(801) 227-8019
Region Four	Troy Torgersen	(435) 893-4707

TRAFFIC SIGNAL SYSTEM INSPECTION

Region One	Dale Lake	(801) 620-1606
Region Two	Troy Noall	(801) 887-3659
Region Three	Grant Jackson	(801) 227-8040
Region Four	Clay Cottam	(435) 590-9976
ITS (Fiber Optic Cable)	Craig Wright	(801) 887-3764
Statewide Training	Bill Butterfield	(801) 887-3748
	Rich Williams	(801) 887-3603

STATE FURNISHED MATERIALS

Signal Hardware	Katie Knaus	(801) 965-4270
Signal Hardware Requisition	Amber Routson	(801) 965-4195
UDOT Warehouse Inventory	Doug Snedden	(801) 965-4755
UDOT ITS Hardware	Bob Pieper	(801) 887-3760
UDOT Sign Shop	Doug Fehrmann	(801) 965-4281

SIGNAL SYSTEM COORDINATION

Statewide Coordination	Mark Parry	(801) 887-3768
Statewide Technical	Keith Wilde	(801) 887-3708

A.3 UDOT WEBSITE INFORMATION AND DOWNLOADS:

Standards and Specifications – Electronic Plan Room
http://www.udot.utah.gov/index.php?m=c&tid=317

CADD Documents – Standards
http://www.udot.utah.gov/index.php/m=c/tid=77

Traffic and Safety – Summary Sheets, Forms, and Guidelines
http://www.udot.utah.gov/index.php/m=c/tid=579

A.4 STATE FURNISHED MATERIAL REQUISITION PROCESS

Objectives:

- Save time and eliminate frustration.
- Materials available for project when requested.
- Simplify material pick up process for contractor.
- Eliminate handwritten over the counter requisition.

Communication is the key!

UDOT Contacts:

Design Engineer or Consultant, Project Manager (P.M.), Resident Engineer (R.E.), and Contractor

Traffic and Safety –

Amber Routson, Secretary	965-4195	965-4736 fax
Katie Knaus, Engineering Intern	965-4270	
Larry Montoya, Traffic & Safety Design	965-4924	

Central Warehouse –

Warehouse Desk	965-4060	965-4818 fax
Doug Snedden, Inventory Mgr.	965-4755	
Tracie Montano, Supply/Materials Mgr.	964-4534	

Region Electronics Supervisor –

Dale Lake, Region One	620-1606	627-8196 fax
Bob Pieper, TOC/Region Two	887-3760	887-3797 fax
Grant Jackson, Region Three	227-8040	227-8049 fax
Clay Cottam, Region Four	(435) 590-9976	(435) 865-5564 fax

Sign Shop –

Doug Fehrmann, Sign Shop Mgr.	965-4281	964-4426 fax

How the Process Works

Design Phase:

1. **Design Engineer** –
    - Contact Electronics supervisor early in the design process to determine the type and brand of controller required for each signal location and application.

    - Finalize list of State Furnished Materials after PS&E review and prior to Final plan review. Minimize the likelihood of field changes.

    - Submit one intersection per State Furnished Items Form.

    - Email State Furnished Items Form to Amber Routson. Carbon copy the P.M., R.E., Katie Knaus, and Region Electronics Supervisor (Dale Lake, Bob Pieper, Grant Jackson, Clay Cottam).

2. **Amber Routson** –
    - Print requisition forms. The State Furnished Items Form automatically creates five separate requisition sheets: 1. Signal Pole Materials; 2. Controller and Cabinet; 3. Video Detection/LED's; 4. Anchor Bolts; and 5. Misc. Signal Equipment (modem, astro-brac, signal heads, etc.) This final sheet will be used primarily for State Forces.

Construction Phase:

1. **R.E.** –
    - Provide Amber Routson with name of contractor, and approximate time-frame contractor will need State Furnished Materials after preconstruction meeting.

2. **Amber Routson** –
    - Enter the requisition forms into FINET.

3. **R.E.** –
    - Contact Katie Knaus approximately 2-3 weeks before materials will be picked up.

    - Contact Region Electronics Supervisor approximately 2-3 weeks before cabinet is needed.

4. **Region Electronics Supervisor** –
    - Contact Doug Snedden to schedule pickup date for signal controller and cabinet. 48-hours advance notice is required. *Note: Cabinet and Controller for Regions One and Four are typically shipped via weekly Region Transport.*

5. **Katie Knaus** –
    - Meet weekly with Doug Snedden to review and update contractor schedule for material pickup.

6. **Contractor** –
    - Contact Doug Snedden or Warehouse Desk to schedule a date and time to pick up materials from the warehouse. 48-hours advance notice is required.

    - Contact Region Electronics Supervisor to schedule a date and time to pick up signal controller and cabinet from the Region signal lab.

Material Return (Stock Return):

1. **R.E.** –
    - Contact Katie Knaus with details of the change.

2. **Katie Knaus** –
    - Check availability of the item needed and relay this information to the R.E.

3. **R.E.** –
    - Complete Stock Return Transaction Form. Ensure all components are listed including hardware kits.

    - Fax completed form to Doug Snedden and carbon copy Katie Knaus.

4. **Contractor** –
    - Contact Doug Snedden to schedule date for material drop off. 48-hours advance notice is required.

    - Responsible for returning all items listed on the Stock Return Transaction Form.

5. **Warehouse** –
    - UDOT will not accept items that are missing components, used, or not packaged in the original box. Doug Snedden will contact the R.E. and inform him of materials not returned.

6. **R.E.** –
    - With hold Contractor retention until the items are returned or UDOT is reimbursed for the cost of the items missing.

Tips for Completing the State Furnished Items Form:

- R.E. – Provide contact information including name of the electrical contractor.

- Everyone – Check quantities:
  Poles and mast arms
  Anchor bolts for poles (four required per pole)
  Video detection camera equipment

- Design Engineer – Specify signal controller and cabinet brands. Check with Electronics Supervisor or Keith Wilde at 887-3708, to determine the controller type and brand requirements for each signal location.

- Design Engineer – Submit request for ITS equipment (fiber interconnect equipment, ATMS cabinets, ramp metering) to Bob Pieper. R.E. – Follow up on request after preconstruction meeting.

- Contractor – Provide LEDs for traffic and pedestrian signal heads.

- Contractor – Submit request for mast arm mounted signs to Doug Fehrmann.

- R.E. and Contractor – Decide whether to drop ship the steel hardware (poles, mast arms, anchor bolts, etc.). This decision is based on feasibility and the construction schedule. Plan on 45-50 days to receive the shipment.

- Always double-check your order to ensure correctness before leaving the yard.

Examples:

Case 1 – Contractor discovers unforeseen impact and needs to change the material listed on the initial requisition. Contractor has not picked up the materials yet.

1. **R.E.** –
    - Contact Katie Knaus with details of the change including anticipated pick up date, etc.

2. **Katie Knaus** –
    - Check availability of the item(s) needed and relay this information to the R.E.

    Continue with step 2 listed under the Construction Phase.

Case 2 – Contractor discovers unforeseen impact and needs to change the material he has already picked up. *This case involves returning material and requisitioning new material.*

1. **R.E.** –
    - Contact Katie Knaus with details of the change including anticipated pick up date, etc.

2. **Katie Knaus** –
    - Check availability of the item(s) needed and relay this information to the R.E.

3. **R.E.** –
    - Email completed State Furnished Form to Amber Routson.

4. **Amber Routson** –
    - Print the forms and enter the requisition into FINET.

    Continue with step 3 listed under Material Return.

Case 3 – Contractor informs R.E. that he is missing (or never received) an item that is State Furnished. If our records show that this item was picked up and not back ordered then the Contractor is responsible for this item. The R.E. will deduct the cost of these items from payment to the Contractor.

1. **R.E.** –
    - Contact Katie Knaus with the details including what item is needed, and the anticipated pick up date, etc.

2. **Katie Knaus** –
    - Check availability of the item(s) needed and relay this information to the R.E.

3. **R.E.** –
    - Email completed State Furnished Form to Amber Routson.

    Continue with step 2 listed under Construction Phase.

Work Zones

MEMORANDUM

DEPARTMENT OF TRANSPORTATION

DATE: April 4, 1998

TO : ALL CONSTRUCTION/MAINTENANCE ENGINEERS

FROM : E. Fred Lewis E. Fred Lewis
Traffic and Safety Operations Engineer

SUBJECT: Double Fines in Construction/Maintenance Sites

As you are aware Senate Bill 20 created increased penalties for speeding in construction/maintenance sites. The effective date of the new law is May 4, 1998.

Attached is an informational sheet on the requirements of the law, sign layout and suggested signing sequence. It will be the responsibility of each project engineer/maintenance crew to determine if they want to use this law on their projects and arrange through their contractor to provide and install the signs.

For UDOT maintenance crews signs have been ordered, but are yet to be delivered. When they arrive, they will available in our warehouse.

EFL/cdf

CONSTRUCTION SPEED ZONE LAW

The last legislative session passed Senate Bill 20 which created increased penalties for speeding in construction/maintenance work zones. The effective date of the new law is May 4 1998.

For the law to be effective it requires each construction/maintenance site to be clearly marked and have signs posted warning of the double fine for speeding. To accomplish this requirement we have developed "Double Fine" signs for permanent and portable applications. Permanently mounted signs used on interstate routes are 84"X48" with 8" series C letters and for highways other than interstate, permanently mounted signs will be 72"X36" with 6" series C letters. The legend will read "FINES DOUBLE FOR SPEEDING IN WORK ZONES". Portable signs for maintenance operations and short term construction sites will be 48" diamond shape with 7" series C letters, "FINES DOUBLE FOR SPEEDING". All signs will be black legend and borders on reflective orange background. For UDOT maintenance crews the signs will be made of reflective vinyl (roll up signs).

The new law also requires that the construction/maintenance zone clearly be marked. The first sign posted, "Road Work Ahead" will serve to identify the beginning of the zone and the "End Road Work" will identify the end of the work zone. For UDOT maintenance crews the "End Road Work" sign will be made of aluminum 24"X30".

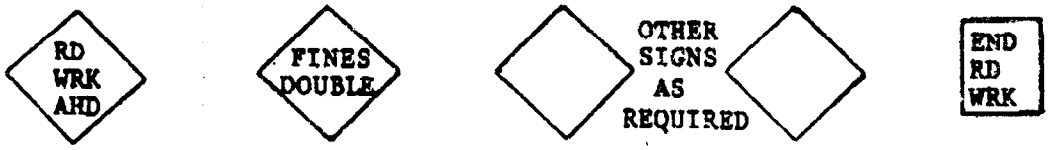
In all situations the law is only effective when workers are present at the work site.

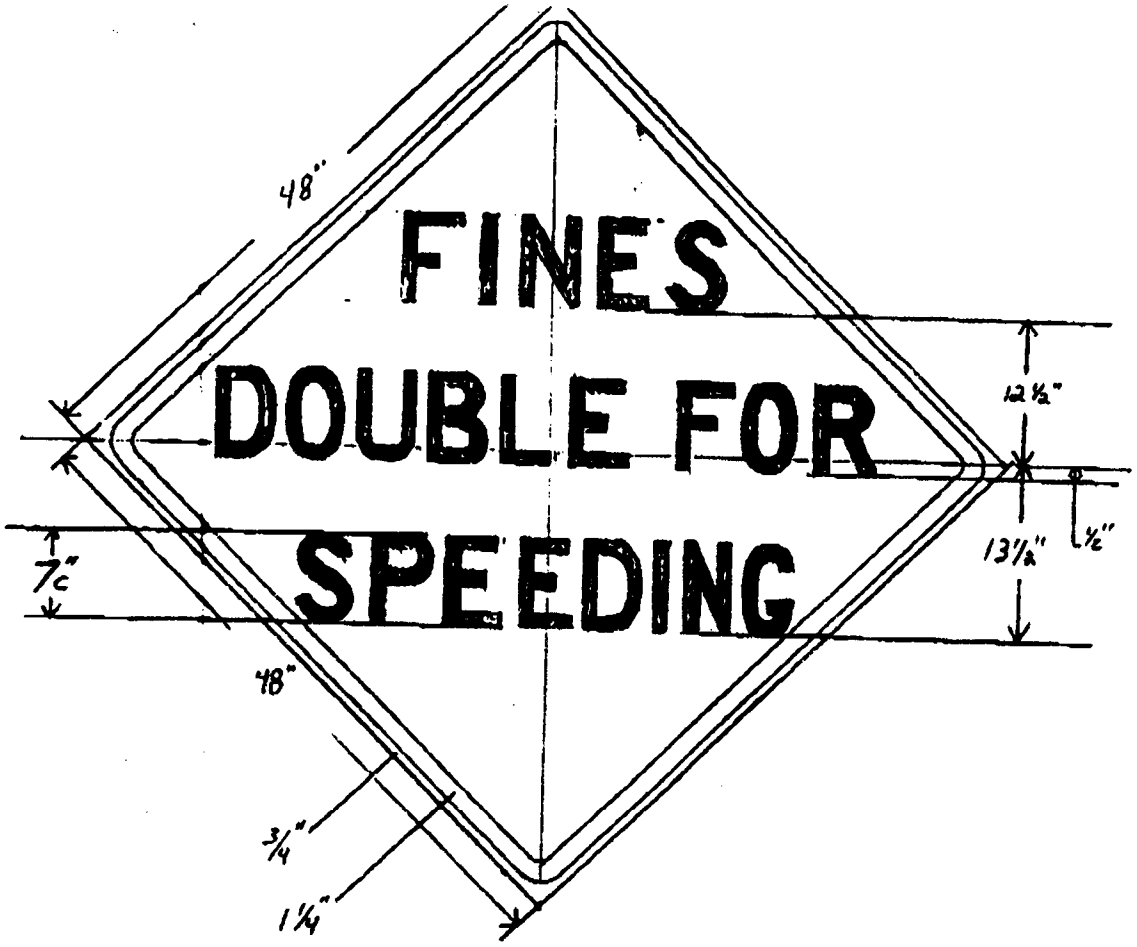
The signing sequence should generally follow:

1. <u>Where the regulatory speed limit is reduced below the existing posted speed limit.</u>
   Existing speed limits should not be reduced more than 10 MPH below the posted speed limit. On interstates 20MPH reductions are acceplable.

* FOR SPEED REDUCTIONS 15MPH OR MORE

2. <u>Where the existing regulatory speed limit is not reduced.</u>





FINES DOUBLE
FOR SPEEDING
IN WORK ZONES

3
6"c
3
6"c
3
6"c
3

6 5
8c 10"c
6 4
8"c 10"c
6 4
8"c 10"c
6 5

6"c 72x30

8"c 84x48 } USE 8" or LARGER for INTERSTATE (POST MOUNT.)
10"c 120x48 }

24x30

END
ROAD
WORK

3
6"c
3
6"c
3
6"c
3

(FOR MAINTENANCE OPERATIONS)

PENALTIES FOR SPEEDING IN CONSTRUCTION ZONES

1998 GENERAL SESSION

STATE OF UTAH

Sponsor: David L. Buhler

AN ACT RELATING TO MOTOR VEHICLES; REQUIRING AN INCREASED FINE FOR SPEEDING VIOLATIONS IN HIGHWAY CONSTRUCTION SITES.

This act affects sections of Utah Code Annotated 1953 as follows:

AMENDS:

41-6-13, as last amended by Chapter 138, Laws of Utah 1987

Be it enacted by the Legislature of the state of Utah:

Section 1. Section **41-6-13** is amended to read:

41-6-13. Obedience to peace officer or other traffic controllers -- Speeding in construction zones.

(1) A person may not willfully fail or refuse to comply with any lawful order or direction of any peace officer, fireman, flagger at a highway construction or maintenance site, or uniformed adult school crossing guard invested by law with authority to direct, control, or regulate traffic.

(2) When flaggers at highway construction or maintenance sites are directing traffic, they shall use devices and procedures conforming to the [~~latest edition of the "Manual on Uniform Traffic Control Devices for Streets and Highways."~~] standards adopted under Section 41-6-20.

(3) (a) A vehicle operator who commits a speeding violation in a highway construction or maintenance site where workers are present shall have a fine imposed by the court that is at least double the fine in the uniform recommended fine schedule established under Section 76-3-301.5 for the offense.

(b) The highway construction or maintenance site under Subsection (3)(a) shall be clearly marked and have signs posted that warn of the doubled fine.

How to get NCHRP-350 crash test information

from FHWA web site

http://safety.fhwa.dot.gov/programs/roadside_hardware.htm

from: UDOT, Division of Traffic & Safety

John Leonard (801) 965-4045
jleonard@utah.gov

Glenn Schulte (801) 965-4376
gschulte@dot.state.ut.us

Run-Off-Road: Roadside Hardware

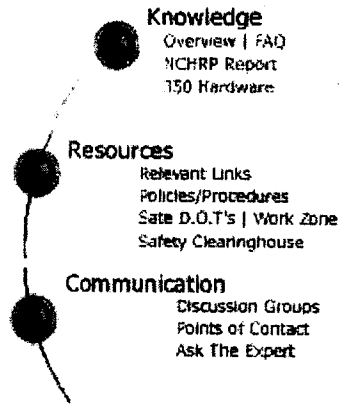
at's New

Professional Resources
Programs
Facts and Data
Media Center

Community Resources
Programs

Road User Resources
Programs
Media Center

News and Events
Press Room
Newsletter



FHWA policy requires that all roadside appurtenances such as traffic barriers, barrier terminals and crash cushions, bridge railings, sign and light pole supports, and work zone hardware used on the National Highway System meet the performance criteria contained in the National Cooperative Highway Research Program (NCHRP) Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features.* This website identifies all such hardware and includes copies of FHWA acceptance letters for each of them. In the case of proprietary items, links are provided to manufacturers' websites as a source of detailed information on specific devices. The site also contains an "Ask the Experts" section where questions on roadside design issues can be addressed.

Back To Top

This website contains information on three general categories of roadside hardware that are tested and evaluated using NCHRP Report 350 criteria. Click on the appropriate category to see information on specific types of hardware.

Traffic Barriers, Barrier Terminals, Crash Cushions, and Bridge Railings

- Longitudinal Barriers
- Barrier Terminals/Crash Cushions
- Bridge Railings

Breakaway Hardware

- Luminaire Supports (including some traffic signal and callboxpoles)
- Sign Supports
- Other/ Miscellaneous hardware

Work Zone Devices

Work Zone Devices

fessional ources
Programs
Facts and Data
Media Center
What's New?

Community Resources
Programs

Road User Resources
Programs
Media Center

News and Events
Press Room

FHWA guidance on crash testing of work zone traffic control devices is contained in two memoranda. The first, dated July 25, 1997, titled "Information: Identifying Acceptable Highway Safety Features," established four categories of work zone devices:

- Category I devices were those lightweight devices which could be self-certified by the vendor.
- Category II devices were other lightweight devices which needed individual crash testing.
- Category III devices were barriers and other fixed or massive devices also needing crash testing.
- Category IV devices were trailer mounted lighted signs, arrow panels, etc.

The second guidance memorandum, "INFORMATION: Crash Tested Work Zone Traffic Control Devices." was issued on August 28, 1998 This more recent memorandum lists devices that are acceptable under Categories I, II, and III, and provides compliance dates for hardware to be used on the National Highway System. FHWA acceptance of a device for use in work zones on the NHS is limited to the crash-worthiness characteristics of the device and does not cover its structural features or conformity with the *Manual on Uniform Traffic Control Devices*.

Attachment A, Table 2.1 of the August 28, 1998, memorandum listed the letters of acceptance written through May of 1998 on Category II devices.

Questions and Answers About Crash Testing of Work Zone Safety Appurtenances

View current listings of acceptance letters and Work Zone Devices by Code (e.g WZ-1).

Or, Select a keyword from the following list.

Channelizer

Search by Keyword

Acrobat Reader is required for viewing files.

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Michael O. Leavitt
Governor
Thomas R. Warne
Executive Director
John R. Njord
Deputy Director

State of Utah
DEPARTMENT OF TRANSPORTATION

4501 South 2700 West
Salt Lake City, Utah 84119-5998
(801)965-4000
FAX (801) 965-4338
INTERNET www.sr.ex.state.ut.us

June 1, 2000

Richard Thorn, Executive Vice President
Associated General Contractors
1135 South West Temple
Salt Lake City, Utah 84101

Re: *Revised* NCHRP-350, Compliance Dates for Work Zone Devices

Dear Rich:

The Utah Department of Transportation has accepted National Cooperative Highway Research Program Report 350, Recommended Procedures for the Safety Performance Evaluation of Highway Feature (NCHRP-350) as the standard for which devices must comply in order to be used on the State Highway System and the National Highway System. This report deals with the crash worthiness of both permanently placed roadside features and work zone safety devices. NCHRP-350 requires the passing of as many as six different impact tests in order to meet crash worthiness requirements. The manufacturers can do a self certification of some work zone devices. UDOT has already changed their standards to meet NCHRP-350 for permanently installed devices, and require permanently mounted work zone signing to meet NCHRP-350 requirements, see note 3, Standard Drawing 742-2.

FHWA has established four categories for devices requiring testing and dates as to when devices in each of these categories must meet NCHRP-350 standards. It is the feeling of the Division of Traffic and Safety that some devices that are currently in use, could pose a hazard, and will not meet NCHRP-350 requirements. These devices should be retired and replaced by devices that meet the crash testing requirements. Due to the expense that contractors and others could incur, it is felt we can allow the devices now in service to be used for new projects started prior to **April 1, 2002**. All projects started after April 1, 2002 would be required to use devices compliant to NCHRP-350. This allows the use of these devices through this 2000 season, the 2001 construction season and any project started prior to April 1, 2002.

This time period was established after informal discussions with Mr. Lloyd Lefevre, member of the AGC's Heavy Highway Committee, Mr. J.D. McNeil of J.D. McNeil Construction, and Mr. Donald Sutton, Interstate Rock Products, in a meeting held on other traffic control concerns. UDOT's Traffic Engineering Panel has also held discussions on this issue and concluded these devices should meet the NCHRP-350 requirements and removed as soon as possible.

The following is a list of categories and the types of devices in catagory with FHWA implementation dates and UDOT compliance dates:

Category 1 Devices ***FHWA implementation date October 1, 1998***
UDOT compliance date APRIL 1, 2002

Low-mass devices such as: single piece traffic cones, tubular makers, single piece drums, and delineators, without auxiliary lights or signs. Devices in this category shall have manufacturer certification that they meet the requirements of NCHRP 350.

Category 2 Devices ***FHWA implementation date October 1, 2000***
UDOT compliance date APRIL 1, 2002

Devices in Category I with attachments (i.e., lights and signs), vertical panels, types I, II, and III barricades and portable sign supports and signs.

Category 3 Devices ***FHWA implementation date October 1, 1998*** 
UDOT compliance date December 15, 1999

Devices in Category 3, impact attenuators, truck mounted attenuators, longitudinal barrier and break away sign supports.

UDOT revised the Guidelines for Attenuators & End Sections (December 15, 1999) in which devices are NCHRP-350 tested and accepted.

Any non compliant permanent attenuators purchased prior to December 15, 1999, but not installed, may be used.

The G-R-E-A-T CZ, a construction zone attenuator system, is not NCHRP-350 compliant, but may be used until such time it is no longer economically feasible to repair.

All truck mounted attenuators: existing units, which do not meet NCHRP 350, may be used until such time they are no longer economically feasible to repair. New systems purchased after October 1, 2000 must be NCHRP-350 tested and accepted.

The precast barrier being used by the department meets the criteria as stated in the FHWA memo.

Permanently mounted work zone signing. UDOT requires all work zone signing using permanently mounted sign systems, to meet NCHRP-350 requirements, see Note 3, Standard Drawing 745-2.

Category 4 Devices ***FHWA implementation date none announced***
UDOT compliance date, none established

Devices in category 4 include, portable, usually trailer mounted, devices such as lighting supports, flashing arrow panels, temporary traffic signals, and portable message signs. At this time there are no devices in this category which meet NCHRP-350 testing requirements. Those devices now in service can remain in service.

Manufacturers of devices in all categories are aware of the NCHRP-350 requirements and have been aggressively testing their devices to the new standards. There are a multitude of devices now on the market that meet the new requirements. Generally the work zone devices now available will meet UDOT standards.

If you have any further question regarding this issue or other issues concerning crash testing requirements for safety features and appurtenances, or on a products acceptability please contact me at 965-4264 or Glenn Schulte at 965-4376.

Sincerely,

By.

Mack O. Christensen, P.E.
Traffic and Safety Studies Engineer

MOC/GS/ec

cc: Tom Warne
John Njord
Sterling Davis
Thomas Smith

School Zones

SCHOOL ZONE SAFETY ACT

1992

GENERAL SESSION

Enrolled Copy

H. B. No. 32

By Michael G. Waddoups

H. Craig Moody

David S. Ostler

Kim R. Burningham

AN ACT RELATING TO MOTOR VEHICLES; DEFINING A REDUCED SPEED SCHOOL ZONE; REQUIRING USE OF SCHOOL SPEED LIMIT SIGNS AND SCHOOL CROSSING GUARDS IN CERTAIN CIRCUMSTANCES; REQUIRING THE TRANSPORTATION COMMISSION TO MAKE CERTAIN RULES; ESTABLISHING A MAXIMUM SPEED LIMIT FOR SCHOOL ZONES UNDER CERTAIN CONDITIONS; SETTING MINIMUM PENALTIES FOR VIOLATING THE SPEED LIMIT IN A SCHOOL ZONE UNDER SPECIFIED CONDITIONS; REQUIRING LOCAL AUTHORITIES TO PROVIDE SCHOOL CROSSING GUARDS OR SHUTTLE SERVICE AND TO OPERATE AND MAINTAIN SCHOOL ZONES; REQUIRING SCHOOL BOARDS TO ESTABLISH A SCHOOL TRAFFIC SAFETY COMMITTEE AND PROVIDE CHILD ACCESS ROUTING PLANS AND TRAINING; APPROPRIATING $500,000 TO PURCHASE SIGNS; AND MAKING TECHNICAL CHANGES.

THIS ACT AFFECTS SECTIONS OF UTAH CODE ANNOTATED 1953 AS FOLLOWS:

AMENDS:

41-6-20, AS LAST AMENDED BY CHAPTER 138, LAWS OF UTAH 1987

41-6-46, AS LAST AMENDED BY CHAPTER 44, LAWS OF UTAH 1991

41-6-78, AS LAST AMENDED BY CHAPTER 138, LAWS OF UTAH 1987

53A-3-402, AS LAST AMENDED BY CHAPTER 78, LAWS OF UTAH 1990

ENACTS:

41-6-20.1, UTAH CODE ANNOTATED 1953

41-6-48.5, UTAH CODE ANNOTATED 1953

Be it enacted by the Legislature of the state of Utah:

Section 1. Section 41-6-20, Utah Code Annotated 1953, as last amended by Chapter 138, Laws of Utah 1987, is amended to read:

41-6-20. Manual and specifications for uniform system of traffic-control devices and school crossing guards.

(1) (a) The Transportation Commission shall adopt a manual and specifications for a uniform system of traffic-control devices consistent with the provisions of this chapter for use upon highways within this state.

(b) The manual shall correlate with, and where possible conform to, the system set forth in the [~~most-recent-revised~~] 1988 edition of the "Manual on Uniform Traffic Control Devices for Streets and Highways" and other standards issued or endorsed by the federal highway administrator.

(2) The Transportation Commission shall adopt a manual and specifications for a uniform system of traffic-control devices and school crossing guards for school crossing zones, which shall supplement [~~Part VII of~~] the manual adopted under Subsection (1).

Section 2. Section 41-6-20.1, Utah Code Annotated 1953, is enacted to read:

41-6-20.1. Definition of reduced speed school zone -- Operation of warning lights -- School crossing guard requirements -- Responsibility provisions -- Rulemaking authority.

(1) As used in this section "reduced speed school zone" means a designated length of a highway extending from a school speed limit sign while the warning lights are operating to an end school zone sign.

(2) (a) Before January 1, 1993, the Department of Transportation on state highways and local authorities on highways under their jurisdiction:

(i) shall establish reduced speed school zones in compliance with this section at elementary schools; and

(ii) may establish reduced speed school zones for secondary schools at the request of the local authority.

(b) Notwithstanding Subsection (a), the Department of Transportation may not establish a reduced speed school zone at an elementary school without written assurance by a local authority that the local authority will comply with Subsections (3) and (4).

(3) (a) For all reduced speed school zones on highways, including state highways within the jurisdictional boundaries of a local authority, the local authority shall:

(i) (A) provide shuttle service across highways for school children; or

(B) provide, train, and supervise school crossing guards in accordance with this section; and

(ii) provide for the:

(A) operation of reduced speed school zones, including providing power to warning lights and turning on and off the warning lights as required under Subsections (4) and (5); and

(B) maintenance of reduced speed school zones.

(b) Notwithstanding Subsection (a)(ii)(B) the department shall provide for the maintenance of reduced speed school zones for state highways as required under Section 41-6-21.

(4) While children are going to or leaving school during opening and closing hours all reduced speed school zones shall have:

(a) the warning lights operating on each school speed limit sign; and

(b) a school crossing guard present if the reduced speed school zone is for an elementary school.

(5) The warning lights on a school speed limit sign may not be operating except as provided under Subsection (4).

(6) The Transportation Commission shall make rules in accordance with Chapter 46a, Title 63, Utah Administrative Rulemaking Act, establishing criteria and specifications for the:

(a) establishment, location, and operation of school crosswalks, school zones, and reduced speed school zones;

(b) training, use, and supervision of school crossing guards at elementary schools and secondary schools; and

(c) content and implementation of child access routing plans under Section 53A-3-402.

(7) Each local authority shall pay for providing, training, and supervising school crossing guards in accordance with this section.

Section 3. Section 41-6-46, Utah Code Annotated 1953, as last amended by Chapter 44, Laws of Utah 1991, is amended to read:

41-6-46. Speed regulations -- Safe and appropriate speeds at certain locations -- Prima facie speed limits -- Rulemaking -- Emergency power of the governor.

(1) A person may not operate a vehicle at a speed greater than is reasonable and prudent under the existing conditions, giving regard to the actual and potential hazards then existing, including when:

(a) approaching and crossing an intersection or railroad grade crossing;

(b) approaching and going around a curve;

(c) approaching a hill crest;

(d) traveling upon any narrow or winding roadway; and

(e) special hazards exist due to pedestrians, other traffic, weather, or highway conditions.

(2) [Where] If no special hazard exists, and subject to Subsection (5) and Sections 41-6-47 and 41-6-48, the following speeds are lawful:

(a) until January 1, 1993, 20 miles per hour when passing a school building or its grounds during school recess or while children are going to or leaving school during opening or closing hours unless a physical barrier prevents access to the highway from the school building or its grounds;

(b) 25 miles per hour in any urban district;

(c) 65 miles per hour on highways where this speed limit does not impair the ability of the state to qualify for federal highway funds; and

(d) 55 miles per hour in other locations.

(3) Except as provided in Section 41-6-48.5, any speed in excess of the limits provided in Subsection (2) is prima facie evidence that the speed is not reasonable or prudent and that it is unlawful.

(4) The Transportation Commission shall make rules in accordance with Chapter 46a, Title 63, Utah Administrative Rulemaking Act, governing size and location of physical barriers provided for in Subsection (2).

(5) The governor by proclamation in time of war or emergency may change the speed limits on the highways of the state.

Section 4. Section 41-6-48.5, Utah Code Annotated 1953, is enacted to read:

41-6-48.5. **Maximum speed in a school zone -- Penalty -- Minimum fines -- Community service -- Recordkeeping.**

(1) A person may not operate a vehicle at a speed greater than 20 miles per hour:

(a) in a reduced speed school zone as defined in Section 41-6-20.1; or

(b) until January 1, 1993, in a school zone when the warning lights of a school speed limit sign are operating.

(2) (a) A violation of this section is a class C misdemeanor and the minimum fine:

(i) for a first offense shall be calculated according to the following schedule:

Vehicle Speed	Minimum Fine
21-29 MPH	$ 50
30-39 MPH	$ 100

40 MPH and greater	$ 250

(ii) for a second and subsequent offense within three years of a previous conviction or bail forfeiture shall be calculated according to the following schedule:

Vehicle Speed	Minimum Fine
21-29 MPH	$ 50
30-39 MPH	$ 200
40 MPH and greater	$ 500

(b) (i) The court may order the person to perform community service in lieu of the fine or any portion of the fine.

(ii) If the court orders community service under this subsection, the court shall make the reasons for the decision a part of the record.

(3) The Driver License Division shall develop and implement a record system to distinguish:

(a) a conviction or bail forfeiture under this section from other convictions; and

(b) between a first and subsequent conviction or bail forfeiture under this section.

(4) The provisions of this section take precedence over the provisions of Sections 41-6-46, 41-6-47, 41-6-48, and 76-3-301.

Section 5. Section 41-6-78, Utah Code Annotated 1953, as last amended by Chapter 138, Laws of Utah 1987, is amended to read:

41-6-78. **Pedestrians' right-of-way -- Duty of pedestrian.**

(1) (a) [When] Except as provided under Subsection (2), when traffic-control signals are not in place or not in operation, the

operator of a vehicle shall yield the right-of-way, slowing down or stopping if necessary to yield, to a pedestrian crossing the roadway within a crosswalk when the pedestrian is upon the half of the roadway upon which the vehicle is traveling, or when the pedestrian is approaching so closely from the opposite half of the roadway as to be in danger. This subsection does not apply under conditions of Subsection 41-6-79 (2).

(b) A pedestrian may not suddenly leave a curb or other place of safety and walk or run into the path of a vehicle which is so close as to constitute an immediate hazard.

(2) The operator of a vehicle approaching a school crosswalk shall come to a complete stop at the school crosswalk if:

(a) a school speed limit sign has the warning lights operating; and

(b) the crosswalk is occupied by any person.

[~~(2)--When~~] (3) If a vehicle is stopped at a marked crosswalk or at any unmarked crosswalk at an intersection to permit a pedestrian to cross the roadway, the operator of any other vehicle approaching from the rear may not overtake and pass the stopped vehicle.

Section 6. Section 53A-3-402, Utah Code Annotated 1953, as last amended by Chapter 78, Laws of Utah 1990, is amended to read:

53A-3-402. **Board powers -- Use of minimum school program funds -- Purchases, sales, and improvements -- Joint construction or operation -- Establish and maintain schools -- Enrollment -- Libraries -- Collect damages -- Counseling -- Federal funds -- Safety patrols -- Grants --**

Compliance officer -- School crossing training -- Child access route plans -- Bylaws and rules.

(1) Local school boards shall spend minimum school program funds for programs and activities for which the State Board of Education has established minimum standards or rules under Section 53A-1-402.

(2) (a) A board may purchase, sell, and make improvements on school sites, buildings, and equipment and construct, erect, and furnish school buildings.

(b) School sites or buildings may only be conveyed or sold on board resolution affirmed by at least two-thirds of the members.

(3) (a) A board may participate in the joint construction or operation of a school attended by children residing within the district and children residing in other districts either within or outside the state.

(b) Any agreement for the joint operation or construction of a school shall:

(i) be signed by the president of the board of each participating district[~~,~~];

(ii) include a mutually agreed upon pro rata cost[~~,~~]; and

(iii) be filed with the State Board of Education.

(4) A board may establish, locate, and maintain elementary, secondary, and vocational schools.

(5) A board may enroll children in school who are at least five years of age before September 2 of the year in which admission is sought.

(6) A board may establish and support school libraries.

(7) A board may collect damages for the loss, injury, or destruction of school property.

(8) A board may authorize guidance and counseling services for children and their parents or guardians prior to, during, or following enrollment of the children in schools.

(9) (a) A board may apply for, receive, and administer funds made available through programs of the federal government.

(b) Federal funds are not considered funds within the school district budget under Chapter 19 [~~of~~], Title 53A.

(c) Federal funds may only be expended for the purposes for which they are received and are accounted for by the board.

(10) (a) A board may organize school safety patrols and adopt rules under which the patrols promote student safety.

(b) A student appointed to a safety patrol [~~must~~] shall be at least ten years old[~~,~~] and [~~shall~~] have written parental consent for the appointment.

(c) Safety patrol members may not direct vehicular traffic or be stationed in a portion of a highway intended for vehicular traffic use.

(d) [~~No--liability~~] Liability may not attach to a school district, its employees, officers, or agents or to a safety patrol member, a parent of a safety patrol member, or an authorized volunteer assisting the program by virtue of the organization, maintenance, or operation of a school safety patrol.

(11) (a) A board may on its own behalf, or on behalf of an educational institution for which the board is the direct governing body,

accept private grants, loans, gifts, endowments, devises, or bequests which are made for educational purposes.

(b) These contributions are not subject to appropriation by the Legislature.

(12) (a) A board may appoint and fix the compensation of a compliance officer to issue citations for violations of Subsection 76-10-105 (2).

(b) A person may not be appointed to serve as a compliance officer without the person's consent.

(c) A teacher or student may not be appointed as a compliance officer.

(13) A board shall adopt bylaws and rules for its own procedures.

(14) (a) A board shall make and enforce rules necessary for the control and management of the district schools.

(b) All board rules and policies shall be in writing, filed, and referenced for public access.

(15) A board may hold school on legal holidays other than Sundays.

(16) (a) Each board shall establish for each school year a school traffic safety committee to implement this subsection.

(b) The committee shall be composed of one representative of:

(i) the schools within the district;

(ii) the Parent Teachers' Association of the schools within the district;

(iii) the municipality or county;

(iv) state or local law enforcement; and

(v) state or local traffic safety engineering.

(c) The committee shall:

(i) receive suggestions from parents, teachers, and others and recommend school traffic safety improvements, boundary changes to enhance safety, and school traffic safety program measures;

(ii) review and submit annually to the Department of Transportation and affected municipalities and counties a child access routing plan for each elementary, middle, and junior high school within the district;

(iii) consult the Utah Safety Council and the Division of Family Health Services and provide training to all school children in kindergarten through grade six, within the district, on school crossing safety and use; and

(iv) help ensure the district's compliance with rules made by the Transportation Commission under Section 41-6-20.1.

(d) The committee may establish subcommittees as needed to assist in accomplishing its duties under Subsection (c).

(e) The board shall require each elementary, middle, and junior high school within the district to develop and submit annually to the committee a child access routing plan.

[~~(16)~~] (17) A board shall do all other things necessary for the maintenance, prosperity, and success of the schools and the promotion of education.

Section 7. **Appropriation -- Application -- Distribution of funds.**

(1) There is appropriated from the General Fund to the Department of Transportation $500,000 for fiscal year 1992-93 to purchase new materials

for school speed limit signs, warning lights, and end school zone signs for state, county, and municipality reduced speed school zones.

(2) (a) Each entity required under Section 41-6-20.1 to install new school speed limit signs, warning lights, and end school zone signs shall make application to the Department of Transportation by June 1, 1992, for funds appropriated under this section.

(b) By June 15, 1992, the Department of Transportation shall process the applications and apportion the funds appropriated under this section on a pro rata basis to each entity applying for funds based on the total number and type of signs applied for.

(c) Beginning on July 1, 1992, the Department of Transportation through the Division of Finance shall pay each qualifying entity as provided in this section the amount apportioned under Subsection (b).

TRAFFIC CONTROLS FOR SCHOOL ZONES

PART 7 SUPPLEMENT TO
THE MANUAL ON UNIFORM
TRAFFIC CONTROL DEVICES
MILLENNIUM EDITION

UTAH DEPARTMENT OF
TRANSPORTATION

TRAFFIC AND SAFETY DIVISION

2003 EDITION

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UDOT Region 1
UDOT Region 2
UDOT Region 3
UDOT Region 4
Utah League of Cities and Towns

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TRAFFIC CONTROLS FOR SCHOOL ZONES

PART 7 SUPPLEMENT TO

THE MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES

MILLENNIUM EDITION

PURPOSE

SUPPORT:

To assure uniform design and application of all types of traffic control devices, Utah Code Annotated (UCA) Section 41-6-20(1), requires the Utah Transportation Commission to adopt a manual and specifications for a uniform system of traffic control devices. The manual adopted (in UCA R927-1-1) is the "Manual on Uniform Traffic Control Devices, Millennium Edition," a Federal Highway Administration publication. In addition, UCA Section 41-6-20(2), requires the Utah Transportation Commission to adopt a manual and specifications for a uniform system of traffic-control devices, school crossing guards, and child access routing plans for school crossing zones. This Part 7 Supplement to the Manual on Uniform Traffic Control Devices (MUTCD) satisfies that requirement.

The intent of this supplement to the MUTCD is to standardize, as much as possible, applications of traffic control devices and crossing guards in School Zones on all public highways in the State of Utah.

This supplement is divided into sections that correspond to the applicable sections in the MUTCD. For the convenience of the user, those sections of Part 7 of the MUTCD not changed for this supplement are also included.

The federal final rule adopted January 17, 2001 as the compliance date for the Millennium edition of the MUTCD.

STANDARD:

For installation of new devices or replacement of devices, compliance shall be effective immediately. For devices in good condition, and a notification, the following list of special compliance dates shall apply.

A. Section 7A.02. Notification to UDOT of routing plans that require students to cross railroad tracks - July 1, 2004;

B. Section 7A.12. School Advance Warning (S1-1) sign - removal of School Advance Warning signs from crosswalks at colleges and universities - August 1, 2008;

C. Section 7B.07. Flourescent yellow-green background - upgrading signs listed in 7B.07 to have a flourescent yellow-green background - August 1, 2008;

D. Section 7B.07. Non-School Zone signs with flourescent yellow-green background - replacement of all existing non-School Zone flourescent yellow-green signs with standard colors - August 1, 2008;

E. Section 7B.08. AHEAD (W16-9p) plaque - addition of the AHEAD (W16-9p) plaque below the School Advance Warning (S1-1) sign - August 1, 2008;

F. Section 7B.09. School Advance Warning (S1-1) sign - elimination of crosswalk lines from Crossing signs and use of the Diagonal Arrow (W16-7) plaque - August 1, 2008; and,

G. Section 7B.11. School Speed Limit assembly - shall meet the specifications of UDOT Standard Drawing SN 2 (post-mounted) or SN 3 (overhead) - August 1, 2008.

Where differences occur between the MUTCD and this Supplement, in language or intent, this Supplement shall take precedence.

CHAPTER 7A. GENERAL

Section 7A.01 Need for Standards

STANDARD:

In accordance with UCA 53A-1a-108(1), each public school, in consultation with its local school board, shall establish a School Community Council at the school building level. Each School Community Council shall consist of school employees, including the school's principal, and parents or guardians of students who are attending the school. Parents or guardians who are employed at the school shall be considered school employees. The School Community Council shall consist of, at a minimum, 4 parents and 3 employees (including principal) for middle, junior high and elementary schools, and 6 parents and 5 employees (including principal) for high schools. Additional details concerning the makeup of the Council described above are outlined in UCA 53A-1a-108. Among other responsibilities outlined in UCA 53A-1a-108(2)(a), School Community Councils shall establish child access routing plans for each elementary, middle, and junior high school within the district. The School Community Council shall submit those child access routing plans to the School Traffic Safety Committee. The child access routing plan shall be prepared in accordance with UCA 53A-3-402(16)(e). The School Community Council shall meet on a semi-annual basis as a minimum.

UCA Section 53A-3-402(16), requires that each school board establish a School Traffic Safety Committee composed of members from the district's schools and PTAs, the city or county, state or local law enforcement, and state or local traffic engineering.

Problems or suggestions from parents, teachers, or school administrators involving school traffic safety shall be submitted to the School Traffic Safety Committee for review and recommendations. The School Traffic Safety Committee shall meet on an annual basis as a minimum.

OPTION:

Each School Traffic Safety Committee may establish subcommittees as needed for each district or school.

SUPPORT:

The School Traffic Safety Committee handles specific problems and issues relating to school trip safety for each school in the district. The Committee reviews the child access routing plans prepared by the School Community Councils. When satisfied with those plans, the School Traffic Safety Committee submits each child access routing plan to the appropriate Utah Department of Transportation Regional office, and to all affected municipalities. Please see Appendix D for UDOT Region contact information, including a map of the Regions to determine which Region should receive the child access routing plan. The Committee also recommends school traffic safety improvements, boundary changes for safety, and school safety program criteria.

Section 7A.02 School Routes and Established School Crossings

STANDARD:

The School Community Council for each elementary school shall prepare, and update annually, a child access routing plan. The plan shall show, in map form with text description as a minimum, the walking routes on the street system within the school boundaries, the school location, existing traffic controls, and established school zones. The map shall be readable in black and white print. The plan also shall address the loading and unloading areas for students who ride the bus or arrive at school by another method of transportation. An explanation of the plan, instruction to parents to walk the route with their children, and an outline of areas of concern shall also be included. Each plan shall be reviewed annually by the District's School Traffic Safety Committee. After review by the Committee, the plan shall be sent to the appropriate local and state highway jurisdictions each year before July 1. The child access routing plan shall also be sent, at the beginning of each school year, to parents whose children attend the elementary school. Parents of students who begin attending a school during a school year shall also be provided a copy of the child access routing plan. Principals shall be responsible for distributing the child access routing plans to parents.

SUPPORT:

A typical child access routing plan map is shown in Figure 7A-1.

STANDARD:

Each elementary school shall, as a minimum, present a traffic safety program to its students annually. The program shall include instruction on safe pedestrian and bicycle behavior and the limitations of drivers and traffic control devices.

Each middle and junior high school shall prepare and update annually a child access routing plan. The plan shall show, as a minimum, the school crossings on major highways. The plan shall be submitted to the appropriate local and state highway jurisdictions each year before July 1 of each year.

If a school provides hazardous busing for students within a geographical area, an alternative walking route shall not be shown on the child access routing plan in that area.

OPTION:

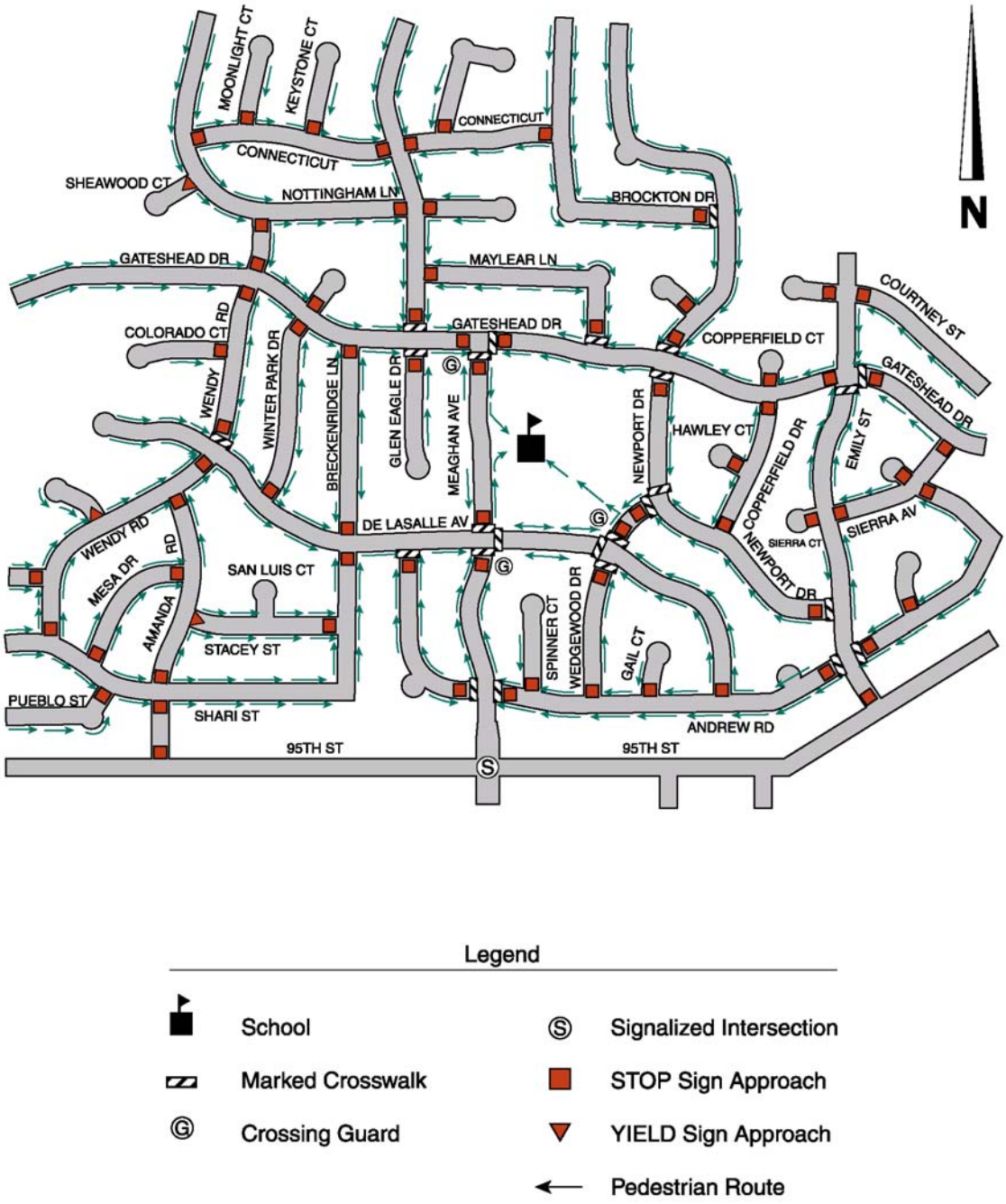
Middle and junior high school child access routing plans may include any elementary school child access routing plans within the middle/junior high school boundaries.

Each high school may also prepare a child access routing plan. High school child access routing plans may include any elementary, middle, or junior high child access routing plans within the high school boundaries.

STANDARD:

A School Zone (see definition in Section 7A.03) shall be placed for a high school only after a child access routing plan detailing each proposed School Zone has been approved by the School Traffic Safety Committee for that high school and submitted to UDOT and the local municipality.

Figure 7A-1. Typical Child Access Routing Plan Map



STANDARD:

Following the yearly review of child access routing plans, school districts shall notify UDOT when a route on a child access routing plan crosses a rail line on any road (state jurisdiction or otherwise). The notification shall be made whether the rail line is judged to be active or inactive. The notification shall be made to the UDOT Chief Railroad and Utilities Engineer at the address given in Appendix D.

Section 7A.03 School Crossing Control Criteria

SUPPORT:

Alternate gaps and blockages are inherent in the traffic stream and are different at each crossing location. For safety, students should wait for a gap in traffic that is of sufficient duration to permit reasonably safe crossing. When the delay between the occurrence of adequate gaps becomes excessive, students might become impatient and endanger themselves by attempting to cross the street during an inadequate gap.

STANDARD:

A School Zone shall be defined as a School Crosswalk, a Reduced Speed School Zone, a Narrow School Route, an Abutting School Zone, or an On-Premise School Bus Loading Zone. School Zones shall only be located at elementary, middle, junior high, and high schools.

A School Zone shall not be installed unless warranted per this section.

A School Crosswalk shall be defined as a marked crosswalk, including the approach to the crosswalk and associated signing. All School Crosswalks shall be designated on an approved child access routing plan. A School Crosswalk shall not have a Reduced Speed School Zone associated with it.

GUIDANCE:

A School Crosswalk should be used if warranted per this section.

STANDARD:

A School Crosswalk shall be warranted when the volume of school children exceeds 10 students during a period extending from not earlier than 45 minutes before school starts until 15 minutes after school starts, or a period from 15 minutes before the end of school to 45 minutes after school ends and the street average daily traffic (ADT) exceeds 500 vehicles.

OPTION:

The volume of school children in the Standard above may be determined by considering both counts and projections.

STANDARD:

If projections are used to determine the volume of school children at a proposed School Crosswalk, an engineering study shall be performed to verify the projections. Supporting data for the study shall include, as a minimum, enrollment information from the school district and a survey of affected parents to define anticipated usage of the proposed School Crosswalk.

A School Crosswalk shall not be installed within 600 feet of another School Crosswalk, a school crosswalk associated with a Reduced Speed School Zone, or a pedestrian crosswalk.

School Crosswalks shall not be installed at any location that has inadequate stopping sight distance as indicated in the most recent edition of "A Policy on Geometric Design of Highways and Streets," American Association of State Highway and Transportation Officials (AASHTO), which edition is incorporated by reference.

The signing for a School Crosswalk shall include the School Advance Warning (S1-1) sign with supplementary plaque(s) and the School Crosswalk Warning assembly (see Sections 7B.08 and 7B.09). Signing and marking of a School Crosswalk shall be as shown in Appendix A, Typical Applications, Sheets A1 through A4.

A <u>Reduced Speed School Zone</u> shall be defined as an area in advance of a school crosswalk, designated on the school child access routing plan, extending from a School Advance Warning (S1-1) sign followed by a School Speed Limit assembly to an END SCHOOL ZONE (S5-2) sign. The Reduced Speed School Zone shall be in-force while the School Speed Limit assembly is operating.

GUIDANCE:

A Reduced Speed School Zone should be used if warranted per this section.

STANDARD:

A Reduced Speed School Zone shall be warranted when all of the following requirements are met:

A. The warrant for installation of a School Crosswalk (see Standard, this Section);
B. The "Requirements for School Crosswalks, Reduced Speed School Zones, and Crossing Guards," contained in Appendix B1; and,
C. The warrant for installation of a Reduced Speed School Zone, contained in Appendix C.

Existing Reduced Speed School Zones that do not meet requirements A, B, and C above shall be removed.

The signing for a Reduced Speed School Zone shall include the School Advance Warning (S1-1) sign with supplementary plaque(s), the School Speed Limit assembly, the School Crosswalk Warning assembly and the END SCHOOL ZONE (S5-2) sign, (see Sections

7B.08, 7B.09, 7B.11, and 7B.13). Signing and marking of a Reduced Speed School Zone shall be as shown in Appendix A, Typical Applications, Sheets A5 through A8.

Except as noted in the Option below, a Reduced Speed School Zone shall not be installed on an approach to an intersection controlled by a traffic signal or by a STOP (R1-1) sign. Existing Reduced Speed School Zones not meeting the Option below shall be removed.

OPTION:

A Reduced Speed School Zone may be installed, or may be allowed to remain at a signalized or stop-controlled intersection as a mitigation measure for concerns relating to sight distance, grade, or other critical issues, determined by an engineering study.

STANDARD:

Installation of an Overhead School Speed Limit assembly in a Reduced Speed School Zone shall be in accordance with the requirements in Appendix B2 and Section 7B.11. Controlling local jurisdictions shall be responsible to apply the warrant process in Appendix B2 for Overhead School Speed Limit assemblies on non-state routes.

On state routes, requests from local jurisdictions or school districts for Overhead School Speed Limit assemblies shall be submitted to the appropriate UDOT Region office (see Appendix D for contact information). After screening each request using the process in Appendix B2, the Region shall forward requests that meet the criteria to the UDOT Engineer for Traffic and Safety. The Traffic and Safety Division shall:

A. Establish priorities for funding Overhead School Speed Limit assembly requests;
B. Program Overhead School Speed Limit assembly projects according to priorities and available funding; and,
C. Initiate agreements on each location according to the following guidelines:
  1. Design and installation shall be the responsibility of the Traffic and Safety Division;
  2. Maintenance of the Overhead School Speed Limit assembly shall be the responsibility of UDOT;
  3. Power and operating costs shall be the responsibility of the local agency; and,
  4. Overhead School Speed Limit assemblies at new schools shall not be funded, in part or in whole, by UDOT.

Overhead School Speed Limit assemblies shall not be installed in a Reduced Speed School Zone on an approach to a signalized intersection.

OPTION:

An existing Overhead School Speed Limit assembly on an approach to an intersection upgraded to signalized control may be allowed to remain in place based on sight distance, grade, or other critical issues determined by an engineering study.

STANDARD:

If an existing Overhead School Speed Limit assembly is allowed to remain at an intersection upgraded to signalized control, the Overhead School Speed Limit assembly shall be located at least 300-feet from the stop line at the intersection.

A Narrow School Route shall be defined as a school route designated in a child access routing plan where there are no continuous sidewalks and the paved shoulders of the existing highway are less than three feet wide.

OPTION:

A Narrow School Route may be used if warranted per this section.

STANDARD:

A Narrow School Route shall be warranted when the School Traffic Safety Committee has determined that boundary changes, alternate school routes, or supplemental methods of transportation are not feasible. Narrow School Routes shall be reviewed by the School Traffic Safety Committee one year after installation and on an annual basis thereafter. The maximum length of a Narrow School Route shall be one mile in urban areas and two miles in rural areas.

If used, the signing for a Narrow School Route shall include the School Advance Warning (S1-1) sign with the NEXT X MILE(S) (W7-3a) plaque (see Section 7B.08). The distance shall be displayed in ¼-mile increments up to a maximum of one mile in urban areas and in ½-mile increments up to a maximum of two miles in rural areas. Signing and marking of a Narrow School Route shall be as shown in Appendix A, Typical Applications, Sheets A9.

GUIDANCE:

A Narrow School Route should not be installed as a permanent substitute for sidewalks or pavement widening in urban areas.

STANDARD:

An Abutting School Zone shall be defined as an area adjacent to school buildings or grounds, including the approach to such areas, with no associated School Crosswalks or Reduced Speed School Zones.

OPTION:

An Abutting School Zone may be used.

STANDARD:

If used, signing for an Abutting School Zone shall include the School Advance Warning (S1-1) sign, and shall not be supplemented with the AHEAD (W16-9p) plaque. For year-round schools, the School Advance Warning (S1-1) sign shall be supplemented with the ALL YEAR (SS1-1) plaque (see Section 7B.08 and Appendix A, Typical Applications, Sheets A10).

An On-Premise School Bus Loading Zone shall be defined as an area on school property designated for the loading and unloading of students from school buses, including the associated signing and pavement markings. All On-Premise School Bus Loading Zones shall be identified on the school's child access routing plan.

With the exception of the option below, On-Premise School Bus Loading Zones shall:

A. be separate from private vehicle loading and unloading areas;
B. be located so that students are not required to cross roadways or parking lot areas to access the school;
C. be located such that buses are not required to back up; and,
D. be at least 12-feet wide.

All newly constructed schools shall meet the standard for On-Premise School Bus Loading Zones.

OPTION:

Existing On-Premise School Bus Loading Zones may be allowed exceptions to Standards A through D above if those zones are demonstrated by the School Community Council to the School Traffic Safety Committee to have unusual conditions.

Section 7A.04 Scope

STANDARD:

Part 7 sets forth basic principles and prescribes standards that shall be followed in the design, application and installation, and maintenance of all traffic control devices and other controls required for the special pedestrian conditions in School Zones. Such devices and controls include signs, signals, markings, adult crossing guards, student patrols, and grade-separated crossings.

Portable school signs shall not be used.

SUPPORT:

Requirements discussed in Chapter 2A and Section 2B.05 are applicable in School Zones.

Section 7A.05 Application of Standards

SUPPORT:

Sections 1A.02 and 1A.07 contain information regarding the application of standards.

Section 7A.06 Engineering Study Required

SUPPORT:

Section 1A.09 contains information regarding engineering studies.

Section 7A.07 Maintenance of Traffic Control Devices

SUPPORT:

Section 1A.05 contains information regarding the maintenance of traffic control devices.

Section 7A.08 Placement Authority

SUPPORT:

Section 1A.08 contains information regarding placement authority for traffic control devices.

Section 7A.09 Removal of Confusing, Distracting, or Obstructing Elements

SUPPORT:

Section 1A.08 contains information regarding the removal of confusing advertising.

STANDARD:

With the exception of required signing and striping, the controlling jurisdiction shall have the authority to immediately remove any signs, messages, or vegetation from within its right of way in or near a School Zone which it deems to be confusing, distracting, or obstructing to the function of that School Zone.

Section 7A.10 Meaning of Standard, Guidance, Option, and Support

SUPPORT:

The INTRODUCTION to the MUTCD contains information regarding the meaning of the headings Standard, Guidance, Option, and Support, and the use of the words shall, should, and may.

Section 7A.11 Experimentation in School Zones

STANDARD:

In order to better coordinate experimentation in School Zones statewide, UDOT shall facilitate all proposals to the Federal Highway Administration to experiment in School Zones. Proposals for experimentation in School Zones shall be submitted to the UDOT Engineer for Traffic and Safety (see Appendix D for contact information).

The UDOT Engineer for Traffic and Safety shall make all submissions for experimentation in School Zones to the Federal Highway Administration, following the procedure described in Section 1A.10 of the MUTCD.

Section 7A.12 Private Schools, Charter Schools, Colleges, and Universities

STANDARD:

The requirements and specifications of this manual shall apply to charter schools using the same age group classifications that public elementary, middle, junior high, and high schools use. Private schools shall be required to meet the requirements and specifications of this manual when requesting any feature described herein to be installed on a public right-of-way using the same age group classifications that public elementary, middle, junior high, and high schools use.

Crosswalks associated with colleges and universities shall not be signed or marked as School Zones. Existing pedestrian facilities signed and/or marked as School Zones at colleges and universities shall be removed. Pedestrian facilities for college and universities shall be treated as described in the MUTCD.

OPTION:

Added emphasis to warning signs associated with pedestrian crosswalks may be achieved using the fluorescent yellow background or by using larger sign sizes (see MUTCD, Table 2C-2).

CHAPTER 7B. SIGNS

Section 7B.01 Size of School Signs

STANDARD:

The sizes of the signs and plaques to be used on conventional roadways in School Zones shall be as shown in Table 7B-1.

The standard sign size shall be used on public roads, streets, and highways unless engineering judgement determines that a special sign size would be more appropriate.

The special sign size shall be used on expressways.

OPTION:

The special sign size may be used for applications that require increased emphasis, improved recognition, or increased legibility.

Table 7B-1. Size of School Zone Signs and Plaques

Sign/Plaque	MUTCD Code	Conventional Roads	
		Standard	Special
SIGNS			
School Advance Warning	S1-1	36 x 36 in	48 x 48 in
SCHOOL BUS STOP AHEAD	S3-1	30 x 30 in	36 x 36 in
SCHOOL SPEED LIMIT 20 WHEN FLASHING	S5-1	24 x 48 in	36 x 72 in
END SCHOOL ZONE	S5-2	24 x 30 in	36 x 48 in
REDUCED SPEED AHEAD	R2-5a	24 x 30 in	36 x 48 in
School Buses Only (symbol)	SS1-2	12 x 24 in	-
SCHOOL BUSES ONLY	SS1-3	12 x 18 in	-
PLAQUES			
AHEAD	W16-9p	36 x 20 in	48 x 30 in
Diagonal Arrow	W16-7	36 x 18 in	48 x 30 in
ALL YEAR	SS1-1	36 x 18 in	48 x 30 in
NEXT X MILE(S)	W7-3a	36 x 24 in	48 x 30 in
SCHOOL	S4-3	36 x 12 in	48 x 16 in

Section 7B.02 Illumination and Reflectorization

STANDARD:

The signs used for School Zone traffic control shall be reflectorized or illuminated.

Section 7B.03 Position of Signs and Cones

STANDARD:

Position of signs shall be as prescribed in Appendix A, Sheets A1 through A10.

Portable school signs shall not be placed within the roadway at any time.

Cones shall be used at all locations when adult crossing guards are present. The cones shall be placed on the centerline of the roadway between opposing traffic lanes at each approach to the crosswalk (see Appendix A, Typical Applications, Sheet A5 through A8). Cones shall not be placed on lane lines separating traffic in the same direction, and shall not be placed in travel lanes. The cones shall have a minimum height of 28 inches and shall be orange in color. Auxiliary flags, signs, or lights shall not be used on the cones.

Section 7B.04 Height of Signs

SUPPORT:

Section 2A.18 contains information regarding the mounting height of signs.

Section 7B.05 Installation of Signs

SUPPORT:

Section 2A.21 contains information regarding the installation of signs.

Section 7B.06 Lettering

SUPPORT:

The "Standard Alphabets for Highway Signs and Pavement Markings" contains information regarding sign lettering.

Section 7B.07 Sign Color for School Warning Signs

STANDARD:

The following signs shall have a flourescent yellow-green background with black legend and border:

A. School Advance Warning sign (S1-1);
B. SCHOOL BUS STOP AHEAD sign (S3-1);
C. The SCHOOL portion of the School Speed Limit sign (S5-1);
D. Diagonal Arrow plaque (W16-7);
E. AHEAD plaque (W16-9p);
F. ALL YEAR plaque (SS1-1);
G. NEXT X MILE(S) plaque (W7-3a); and,
H. SCHOOL plaque (S4-3).

The fluorescent yellow-green background shall not be used for any signs (in School Zones or otherwise) other than those listed above.

All new sign installations of the types above, including replacements, shall meet the color requirements in this Standard.

OPTION:

Added emphasis to warning signs other than those listed above may be achieved using a fluorescent yellow background.

STANDARD:

In On-Premise School Bus Loading Zones, the School Buses Only (symbol) (SS1-2) sign and the SCHOOL BUSES ONLY (SS1-3) sign shall have a white background with red legend and border. The bus symbol on the SS1-2 sign shall be black.

Section 7B.08 School Advance Warning Sign (S1-1)

STANDARD:

A School Advance Warning (S1-1) sign shall be installed in advance of all School Crosswalks (see Appendix A, Typical Applications, Sheets A1 through A4) and in advance of the School Speed Limit assembly in a Reduced Speed School Zone (see Appendix A, Typical Applications, Sheets A5 through A8).

A supplementary AHEAD (W16-9p) plaque of the same color, and border shall be installed below the School Advance Warning (S1-1) sign in advance of the school crosswalk (see Appendix A, Typical Applications, Sheets A1 through A8).

A supplementary ALL YEAR (SS1-1) plaque of the same width, color, and border shall be installed between the School Advance Warning (S1-1) sign and the AHEAD (W16-9p) plaque for year-round schools (See Appendix A, Typical Applications, Sheets A1 through A8). The standard size plaque shall use 5 inch series "C" lettering.

A School Advance Warning (S1-1) sign shall be used for Narrow School Routes.

A supplementary NEXT X MILE(S) (W7-3a) plaque (see Appendix A, Typical Applications, Sheet A9) of the same width, color, and border shall be installed below the School Advance Warning (S1-1) sign for Narrow School Routes. The standard size plaque shall use series "C" lettering, with the NEXT lettering 6 inches in height, and the X MILES lettering 5" in height (see Appendix A, Typical Applications, Sheet A9).

If used for an Abutting School Zone, the School Advance Warning (S1-1) sign shall be used and shall not be supplemented with the AHEAD (W16-9p) plaque. For year-round schools, the School Advance Warning (S1-1) sign in an Abutting School Zone shall be supplemented with the ALL YEAR (SS1-1) plaque (see Appendix A, Typical Applications, Sheet A10).

Section 7B.09 School Crosswalk Warning Assembly (S1-1 with Diagonal Arrow)

STANDARD:

The School Crosswalk Warning assembly shall consist of a School Advance Warning (S1-1) sign with a supplementary Diagonal Arrow (W16-7) plaque directly underneath. This sign assembly shall be installed at the marked crosswalk, or as close to it as possible. The School Crossing (S2-1) sign (1988 MUTCD) and the ALL YEAR (SS1-1) plaque shall not be used at the crosswalk. The School Crosswalk Warning assembly shall be used when replacing a School Crossing (S2-1) sign.

The School Crosswalk Warning assembly shall only be used at a School Crosswalk, or at the crosswalk in a Reduced Speed School Zone.

The School Crosswalk Warning assembly shall not be installed on approaches controlled by a STOP (R1-1) sign.

Section 7B.10 SCHOOL BUS STOP AHEAD Sign (S3-1)

GUIDANCE:

The SCHOOL BUS STOP AHEAD (S3-1) sign should be installed in advance of locations where a school bus, when stopped at the bus stop, is not visible for a distance of 500 ft in advance and where there is no opportunity to relocate the bus stop to provide 500 ft of visibility.

OPTION:

The SCHOOL BUS STOP AHEAD (S3-1) sign, may be installed in advance of school bus stops along high speed roadways with limited refuge area for waiting students.

Section 7B.11 School Speed Limit Assembly (S5-1 with a Speed Limit Sign Beacon)

STANDARD:

The School Speed Limit assembly (SCHOOL SPEED LIMIT 20 MPH WHEN FLASHING (S5-1) sign with a Speed Limit Sign Beacon) shall be used only in conjunction with Reduced Speed School Zones and shall be located as near as practical to the required distance from the school crosswalk (See Appendix A, Typical Applications, Sheets A5 through A8). The school speed limit displayed shall be 20 mph. The School Speed Limit assembly shall be in substantial conformance with the specifications of UDOT Standard Drawing SN 2 (post-mounted) or SN 3 (overhead) (see the UDOT website at www.udot.utah.gov). The flashing lights on the Speed Limit Sign Beacon shall flash yellow alternately, left and right.

OPTION:

Incandescent bulbs and 8-inch lenses may be used for the post-mounted School Speed Limit Assembly (see UDOT Standard Drawing SN-2).

STANDARD:

The in-force periods of reduced speed in Reduced Speed School Zones shall be as short a duration as possible, with in-force periods only during pronounced usage. The in-force period shall be a time extending from not earlier than 45 minutes before school starts until 15 minutes after school begins, and a period extending from 15 minutes prior to the end of school, to not later than 45 minutes after school ends. These periods of operation shall apply to all daily school programs. The School Speed Limit Sign Beacon shall not flash continuously throughout the school day.

At installations requiring an adult crossing guard, the School Speed Limit Sign Beacon shall be operated manually and only while the crossing guard is present. Installations which do not require adult crossing guards shall be operated by an automatic timer with a programmable yearly cycle. At such installations, the local authority shall be responsible to program and operate the automatic timer.

The Specific Periods of Operations (S4-1) plaque and the WHEN CHILDREN ARE PRESENT (S4-2) plaque shall not be used.

Section 7B.12 School Reduced Speed Ahead Assembly

OPTION:

The School Reduced Speed Ahead assembly may be used to inform the road users of a Reduced Speed School Zone when engineering judgment indicates that advance notice would be appropriate.

STANDARD:

If used, the School Reduced Speed Ahead assembly shall consist of the REDUCED SPEED AHEAD (R2-5a) sign in combination with the SCHOOL (S4-3) plaque mounted above it.

If used, The School Reduced Speed Ahead assembly shall be installed in advance of a Reduced Speed School Zone (See Appendix A, Typical Applications, Sheets A5 through A8). The spacing of the School Reduced Speed Ahead assembly from the School Advance Warning (S1-1) sign shall be as given in Table 7B-2.

Table 7B-2. School Reduced Speed Ahead Assembly Spacing

Posted Speed Limit (mph)	Spacing to Advance Warning Assembly (ft)[1]
25	100
30	130
35	215
40	340
45	500
50	640

Note:
1. Distance may vary from 0.95 x Spacing to 1.2 x Spacing

Section 7B.13 END SCHOOL ZONE Sign (S5-2)

STANDARD:

The end of a Reduced Speed School Zone shall be marked with an END SCHOOL ZONE (S5-2) sign. The END SCHOOL ZONE (S5-2) sign shall be located as near to 50 feet as practical on the far side of the school crosswalk or on the far side of the intersection in a Reduced Speed School Zone (see Appendix A, Typical Applications, Sheets A5 through A8).

Section 7B.14 Parking and Stopping Signs (R7 and R8 Series)

STANDARD:

Parking shall be restricted upon the side(s) of the highway designated as a Narrow School Route during school hours including loading and unloading periods.

Parking shall be restricted in the approach to school crosswalks in School Zones during school hours including loading and unloading periods. Parking shall also be restricted beyond the crosswalk (see Appendix A, Typical Applications, Sheets A1 through A8).

OPTION:

Parking may be restricted along approaches to the School Advance Warning assembly, and the School Speed Limit assembly. Parking may also be restricted upon all streets immediately abutting the school grounds during school hours including loading and unloading periods.

SUPPORT:

Refer to Sections 2B.34, 2B.35, and 2B.36 of the MUTCD for details of Parking and Stopping signing.

Section 7B.15 On-Premise School Bus Loading Zone Signs (SS1-2 and SS1-3)

STANDARD:

On-Premise School Bus Loading Zone signs, School Buses Only (symbol) (SS1-2) sign and SCHOOL BUSES ONLY (SS1-3) sign, shall be used to mark the beginning and the end of each On-Premise School Bus Loading Zone. Intermediate signs shall be installed at approximate 50-foot spacing within the Zone.

OPTION:

Either the School Buses Only (symbol) (SS1-2) sign or the SCHOOL BUSES ONLY (SS1-3) sign may be used in an On-Premise School Bus Loading Zone.

Figure 7B-1. School Zone Signs

S1-1

W16-9p

School Advance Warning Assembly

OR

S1-1

SS1-1

W16-9p

School Advance Warning Assembly (Year-Round School)

S1-1

W7-3a

Narrow School Route Assembly

S1-1

W16-7

School Crosswalk Warning Assembly

S3-1

SS1-2

SS1-3

S1-1

SS1-1

Abutting School Zone Assembly (Year-Round School)

S5-1

S5-2

S4-3

S2-5a

School Reduced Speed Ahead Assembly

CHAPTER 7C. MARKINGS

Section 7C.01 Functions and Limitations

SUPPORT:

Markings have definite and important functions in a proper scheme of School Zone traffic control. In some cases, they are used to supplement the regulations or warnings provided by other devices, such as traffic signs or signals. In other instances, they are used alone and produce results that cannot be obtained by the use of any other device. In such cases they serve as an effective means of conveying certain regulations, guidance, and warnings that could not otherwise be made clearly understandable.

Pavement markings have limitations. They might be obliterated by snow, might not be clearly visible when wet, and might not be durable when subjected to heavy traffic. In spite of these limitations, they have the advantage, under favorable conditions, of conveying warnings or information to the road user without diverting attention from the road.

Section 7C.02 Standardization of Application

STANDARD:

Each standard marking shall be used only to convey the meaning prescribed for it in the MUTCD.

Section 7C.03 Crosswalk Markings

STANDARD:

Longitudinal crosswalk markings shall be reserved for School Crosswalks and Reduced Speed School Zones (see Standard Drawing ST 9 on the UDOT website at www.udot.utah.gov). Crosswalk and Diagonal (special emphasis) line crosswalk markings shall not be used at School Crosswalks or in Reduced Speed School Zones.

Section 7C.04 Stop and Yield Lines

STANDARD:

Stop lines shall consist of solid white lines extending across approach lanes to indicate the point at which the stop is intended or required to be made. Yield lines shall consist of a row of isosceles triangles pointing toward approaching vehicles extending across approach lanes to indicate the point at which the yield is intended or required to be made (see Standard

Drawing ST 9 on the UDOT website at www.udot.utah.gov).

GUIDANCE:

Stop lines should be 24 in wide. Stop lines should be used to indicate the point behind which vehicles are required to stop, in compliance with a STOP (R1-1) sign or traffic signal. Stop lines at mid-block signalized locations should be placed at least 40 ft in advance of the nearest signal indication (see Section 4D.15).

Yield lines should be used to indicate the point behind which vehicles are required to yield, in compliance with a YIELD (R1-2) sign. The individual triangles comprising the yield line should have a minimum base width of 24 in and a height equal to 1.5 times the base width. The space between the triangles should be 6 in to 12 in.

Stop or yield lines, if used, should be placed 4 ft in advance of and parallel to the nearest crosswalk line, except at roundabouts as provided for in Section 3B.24.

Section 7C.05 Curb markings for Parking Regulations

STANDARD:

Signs shall be used with curb markings in those areas where curb markings are frequently obliterated by snow and ice accumulation, unless the no parking zone is controlled by statute or local ordinance.

GUIDANCE:

When curb markings are used without signs to convey parking regulations, a legible word marking regarding the regulation (such as "No Parking" or "No Standing") should be placed on the curb.

OPTION:

Local authorities may prescribe special colors for curb markings to supplement standard signs for parking regulation.

SUPPORT:

Since yellow and white curb markings are frequently used for curb delineation and visibility, it is advisable to establish parking regulations through the installation of standard signs (see Section 2B.34 through 2B.36).

STANDARD:

Curbs within On-Premise School Bus Loading Zones shall be painted flourescent yellow-green.

Section 7C.06 Pavement Word and Symbol Markings

STANDARD:

Word and symbol markings shall be white in color. Word and symbol markings shall not be used for mandatory messages except in support of standard signs.

GUIDANCE:

Large letters and numerals should be 6-feet or more in height. Letters, numerals and symbols should be in accordance with the "Standard Alphabets for Highway Signs and Pavement Markings."

The longitudinal space between word or symbol message markings, including arrow markings, should be at least four times the height of the characters for low speed roads, but not more than ten times the height of the characters under any conditions.

STANDARD:

Except as noted in the Option below, pavement word and symbol markings shall be no more than one lane in width (see Standard Drawing ST 9 on the UDOT website at www.udot.utah.gov).

OPTION:

The SCHOOL word marking may extend to the width of two approach lanes.

STANDARD:

If the two-lane SCHOOL marking is used, the letters shall be 10-feet or more in height (see Standard Drawing ST 9 on the UDOT website at www.udot.utah.gov).

The two-lane SCHOOL marking shall only be used on highways with an even number of approach lanes. Highways with an odd number of approach lanes shall use a SCHOOL marking in each lane.

The pavement adjacent to the School Advance Warning assembly (S1-1 with supplementary plaques) shall be marked and maintained with the message "SCHOOL" across the traffic lane(s) (see Appendix A, Typical Applications, Sheets A1 through A8).

Section 7C.07 Center, Lane and Edge Lines

STANDARD:

On paved roads, a School Crosswalk or Reduced Speed School Zone shall be marked as follows (see Appendix A, Typical Applications, Sheets A1 through A8):

A. With no two-way left-turn lane (TWLTL), the center line shall be a solid double yellow line between any two travel lanes moving in opposing directions for the entire length of a School Crosswalk or Reduced Speed School Zone (between the School Advance Warning signs in both cases);

B. With a TWLTL, striping shall be as per Part 3 of the MUTCD (also see Appendix A, Typical Applications, Sheets A4 and A6); and,

C. Lane line(s) shall be solid white between any two travel lanes moving in the same direction approaching the crosswalk. The length of the solid white lines shall be based on the posted speed limit (see Appendix A, Typical Applications, Sheets A1 through A8).

GUIDANCE:

On non-paved roads, the standard signing for a School Crosswalk or a Reduced Speed School Zone should be supplemented with the DO NOT PASS (R4-1) sign and the PASS WITH CARE (R4-2) sign.

OPTION:

An 8-inch solid white edge line may be installed on the outside lane for the length of the Narrow School Route (see Appendix A, Typical Applications, Sheet A9).

CHAPTER 7D. SIGNALS

Section 7D.01 General

SUPPORT:

Part 4 of the MUTCD contains information regarding highway traffic signals in School Zones. The School Crossing signal warrant is described in Section 4C.06.

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CHAPTER 7E. CROSSING SUPERVISION

Section 7E.01 Types of Crossing Supervision

SUPPORT:

There are two types of school crossing supervision:

A. Adult control of pedestrians and vehicles by adult guards or law enforcement officers; and,
B. Student control of only pedestrians with student patrols.

Information for the organization, operation and administration of an adult crossing guard program are given in "Civilian Guards For School Crossings" (available from the Traffic Institute of Northwestern University, 405 Church Street, Evanston, IL 60204) and "Adult School Crossing Guards" (available from the American Automobile Association, 1000 AAA Drive, Heathrow, FL 32746).

Information for the organization, administration and operation of a student patrol program are given in "Policies and Practices for School Safety Patrols" (available *from the American Automobile Association, 1000 AAA Drive, Heathrow, FL 32746).*

Section 7E.02 Adult Guards

STANDARD:

Adult crossing guards shall be required at all Reduced Speed School Zones for elementary schools. Adult crossing guards shall also be required at School Crosswalks for elementary schools at signalized intersections where the posted speed limit is 30 mph or greater.

OPTION:

Adult crossing guards may be used at School Crosswalks and Reduced Speed School Zones for middle, junior high, and high schools. Adult crossing guards may also be used at all other School Crosswalks for elementary schools.

STANDARD:

Application of crossing guards and signing shall be in accordance with Appendix B1, "Requirements for School Crosswalks, Reduced Speed School Zones, and Crossing Guards."

For elementary schools, if no adult crossing guard is provided for a Reduced Speed School Zone, then that Reduced Speed School Zone shall be removed, and the school child access routing plan shall be reviewed and changed by the School Community Council.

Section 7E.03 Qualifications of Adult Guards

SUPPORT:

High standards for selection of adult guards are essential.

GUIDANCE:

Adult guards should possess the following qualifications:

A. Average intelligence;
B. Good physical condition, including sight, hearing, and mobility;
C. Mental alertness;
D. Neat appearance;
E. Good character;
F. Dependability; and,
G. Sense of responsibility for safety of students.

OPTION:

A background check may be conducted on potential adult guards by local law enforcement.

Section 7E.04 Uniform of Adult Guards and Student Patrols

STANDARD:

The minimum safety apparel for crossing guards shall include an orange vest with reflective white, yellow, or orange striping.

Section 7E.05 Operating Procedures for Adult Guards

GUIDANCE:

Adult Guards should not direct traffic in the usual law enforcement regulatory sense. In the control of traffic, they should pick opportune times to create a safe gap. At these times, they should stand in the roadway to indicate that pedestrians are about to use or are using the crosswalk, and that all vehicular traffic must stop.

STANDARD:

Adult guards shall daily instruct elementary school children in safe crossing techniques and in general pedestrian safety.

Adult crossing guards shall use a STOP paddle. The STOP paddle shall be the primary hand-signaling device.

The STOP paddle shall be an octagonal shape. The background of the STOP paddle face shall be red with 6-inch capital white letters and border. The paddle shall be 18-inch in size and shall have the word message STOP on both sides. The paddle shall be reflectorized or illuminated when used during hours of darkness.

GUIDANCE:

Adult crossing guards should not park their vehicle in a manner which limits the visibility of signs, markings, students, or other vehicles within a school zone.

Section 7E.06 Law Enforcement Officers

OPTION:

Law enforcement officers may be used for school crossing supervision.

Section 7E.07 Student Patrols

STANDARD:

Student patrols shall not direct vehicular traffic. Student patrols shall not function as law enforcement officers or adult guards, or in the place of law enforcement officers or adult guards.

Section 7E.08 Choice of Student Patrols

GUIDANCE:

Student patrols should be carefully selected. They should be students from the fifth grade or higher. Leadership and reliability should be determining qualities for patrol membership.

Parental approval should be obtained in writing before a student is used as a member of a student patrol.

Section 7E.09 Operating Procedures for Student Patrols

GUIDANCE:

Student patrols should use a flagging device to stop pedestrians behind the curb or edge of the roadway, and should allow them to cross only when there is an adequate gap in traffic.

STANDARD:

Flagging devices used during periods of twilight or darkness shall be retroreflective or illuminated.

Because they are not authorized to direct vehicular traffic, student patrols shall not use a STOP paddle.

Section 7E.10 Training for Adult Crossing Guards

STANDARD:

Adult crossing guards shall be trained, as a minimum, in the following:

A. Qualifications for adult crossing guards;
B. Uniform and equipment;
C. Operation procedures;
D. Traffic rules and regulations; and,
E. Emergency procedures, including first aid and CPR.

Adult crossing guards shall attend a refresher course every year.

Section 7E.11 Legal authority for Adult Guards

STANDARD:

Adult crossing guards shall be provided and regulated by the local jurisdiction for public and charter schools. The local jurisdiction shall also train the adult crossing guards in the use of correct apparel, operation procedures, pedestrian safety, and proper use of pedestrian crossing facilities.

For private schools, required crossing guards shall be provided and regulated by the local jurisdiction only if a funding agreement is established between the private school and the local jurisdiction. If no funding agreement can be reached, no crossing guard shall be provided. In instances where a crossing guard is required as established by a child access routing plan, and no funding agreement is reached, the associated School Crossing and/or Reduced Speed School Zone shall be removed and the child access routing plan revised.

APPENDICES

Appendix A – Typical Applications

- **Sheet A1**: Typical Intersection School Crosswalk - Four-Way Stop-Controlled
- **Sheet A2:** Typical Intersection School Crosswalk - Signal-Controlled
- **Sheet A3**: Typical Intersection School Crosswalk - Two-Way Stop-Controlled
- **Sheet A4**: Typical Midblock School Crosswalk
- **Sheet A5**: Typical Intersection Reduced Speed School Zone - Two-Way Stop-Controlled
- **Sheet A6**: Typical Midblock Reduced Speed School Zone
- **Sheet A7**: Typical Intersection Reduced Speed School Zone - Four-Way Stop-Controlled
- **Sheet A8**: Typical Intersection Reduced Speed School Zone - Signal Controlled
- **Sheet A9**: Typical Narrow School Route
- **Sheet A10**: Typical Abutting School Zone

Appendix B - School Zone Protection Flowcharts

- **Appendix B1**: Requirements for School Crosswalks, Reduced Speed School Zones, and Crossing Guards
- **Appendix B2**: Requirements for an Overhead School Speed Limit Assembly (OSSLA) in a Reduced Speed School Zone

Appendix C – Warrant: Reduced Speed School Zone

Appendix D – Utah Department of Transportation Contact Information and Region Map

APPENDIX A

Typical Applications

SIGNING AND STRIPING PLACEMENT

	POSTED SPEED LIMIT (MPH)	SCHOOL ADVANCE (S1-1) (d)	NO PARKING ZONE LENGTH AT X WALK OR SCHOOL ADVANCE	NO PARKING ZONE LENGTH AFTER X WALK W ≤ 50′	NO PARKING ZONE LENGTH AFTER X WALK 50′ < W ≤ 70′	NO PARKING ZONE LENGTH AFTER X WALK W > 70′	MINIMUM SOLID WHITE LINE LENGTH
	25	250′	60′	40′	25′	20′	150′
	30	325′	85′	50′	35′	25′	150′
	35	400′	115′	70′	50′	35′	200′
	40	475′	150′	90′	65′	45′	250′
*	45	550′	190′	110′	80′	55′	250′
*	50	625′	230′	140′	100′	70′	250′

NOTES:

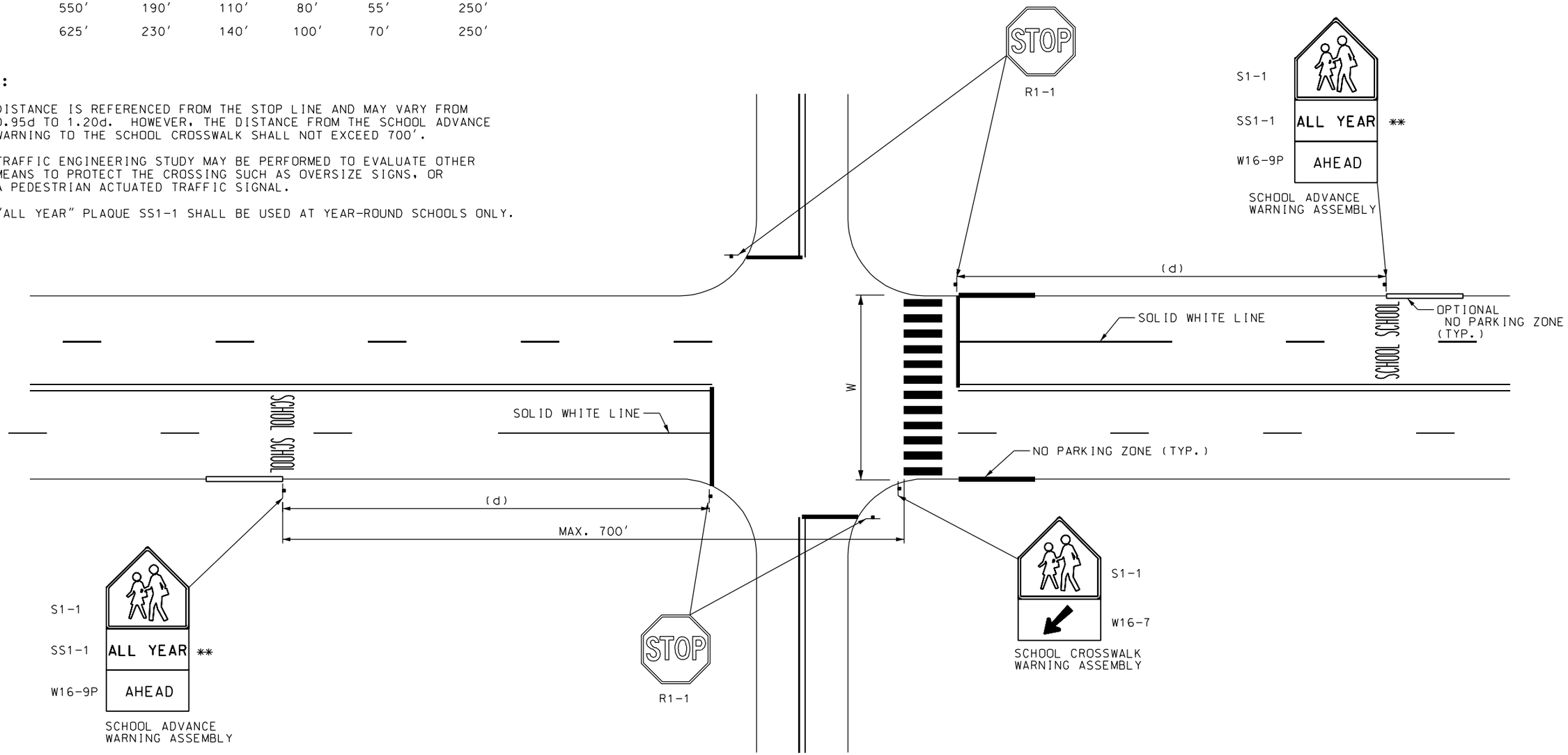
(d) DISTANCE IS REFERENCED FROM THE STOP LINE AND MAY VARY FROM 0.95d TO 1.20d. HOWEVER, THE DISTANCE FROM THE SCHOOL ADVANCE WARNING TO THE SCHOOL CROSSWALK SHALL NOT EXCEED 700′.

* TRAFFIC ENGINEERING STUDY MAY BE PERFORMED TO EVALUATE OTHER MEANS TO PROTECT THE CROSSING SUCH AS OVERSIZE SIGNS, OR A PEDESTRIAN ACTUATED TRAFFIC SIGNAL.

** "ALL YEAR" PLAQUE SS1-1 SHALL BE USED AT YEAR-ROUND SCHOOLS ONLY.

SHEET A1

TYPICAL INTERSECTION SCHOOL CROSSWALK - FOUR-WAY STOP-CONTROLLED



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UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
DIVISION OF TRAFFIC AND SAFETY, DESIGN

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TYPICAL INTERSECTION
SCHOOL CROSSWALK
FOUR-WAY STOP-CONTROLLED

PROJECT NUMBER — APPENDIX A

COUNTY

SHEET NO. A1

SIGNING AND STRIPING PLACEMENT

	POSTED SPEED LIMIT (MPH)	SCHOOL ADVANCE (S1-1) (d)	NO PARKING ZONE LENGTH AT X WALK OR SCHOOL ADVANCE	NO PARKING ZONE LENGTH AFTER X WALK W ≤ 50′	NO PARKING ZONE LENGTH AFTER X WALK 50′ < W ≤ 70′	NO PARKING ZONE LENGTH AFTER X WALK W > 70′	MINIMUM SOLID WHITE LINE LENGTH
	25	250′	60′	40′	25′	20′	150′
	30	325′	85′	50′	35′	25′	150′
	35	400′	115′	70′	50′	35′	200′
	40	475′	150′	90′	65′	45′	250′
*	45	550′	190′	110′	80′	55′	250′
*	50	625′	230′	140′	100′	70′	250′

NOTES:

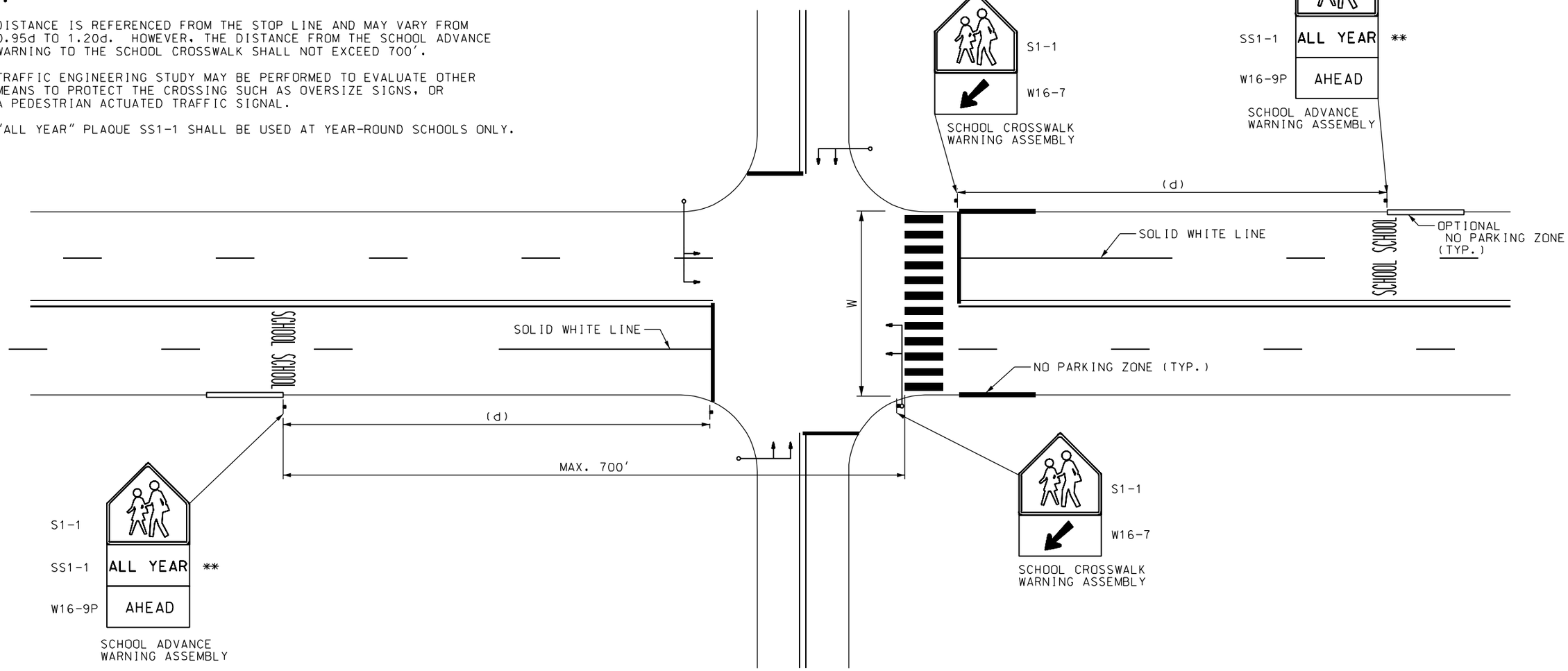
(d) DISTANCE IS REFERENCED FROM THE STOP LINE AND MAY VARY FROM 0.95d TO 1.20d. HOWEVER, THE DISTANCE FROM THE SCHOOL ADVANCE WARNING TO THE SCHOOL CROSSWALK SHALL NOT EXCEED 700′.

* TRAFFIC ENGINEERING STUDY MAY BE PERFORMED TO EVALUATE OTHER MEANS TO PROTECT THE CROSSING SUCH AS OVERSIZE SIGNS, OR A PEDESTRIAN ACTUATED TRAFFIC SIGNAL.

** "ALL YEAR" PLAQUE SS1-1 SHALL BE USED AT YEAR-ROUND SCHOOLS ONLY.

SHEET A2

TYPICAL INTERSECTION SCHOOL CROSSWALK - SIGNAL-CONTROLLED



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TYPICAL INTERSECTION
SCHOOL CROSSWALK
SIGNAL-CONTROLLED

PROJECT NUMBER
APPENDIX A

COUNTY

SHEET NO. A2

SIGNING AND STRIPING PLACEMENT

	POSTED SPEED LIMIT (MPH)	SCHOOL ADVANCE (S1-1) (d)	NO PARKING ZONE LENGTH AT X WALK OR SCHOOL ADVANCE	NO PARKING ZONE LENGTH AFTER X WALK W ≤ 50′	NO PARKING ZONE LENGTH AFTER X WALK 50′ < W ≤ 70′	NO PARKING ZONE LENGTH AFTER X WALK W > 70′	MINIMUM SOLID WHITE LINE LENGTH
	25	250′	60′	40′	25′	20′	150′
	30	325′	85′	50′	35′	25′	150′
	35	400′	115′	70′	50′	35′	200′
	40	475′	150′	90′	65′	45′	250′
*	45	550′	190′	110′	80′	55′	250′
*	50	625′	230′	140′	100′	70′	250′

NOTES:

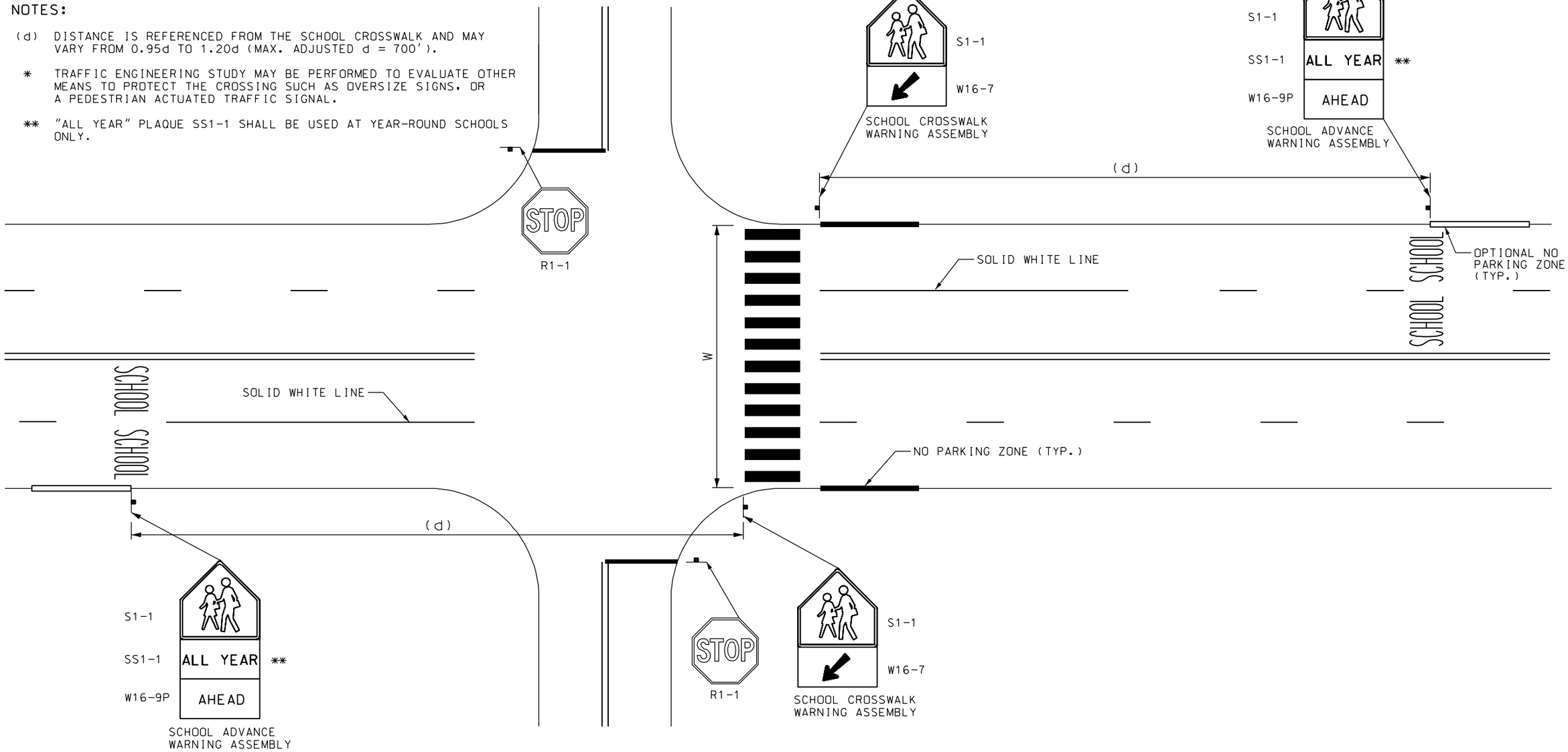
(d) DISTANCE IS REFERENCED FROM THE SCHOOL CROSSWALK AND MAY VARY FROM 0.95d TO 1.20d (MAX. ADJUSTED d = 700′).

* TRAFFIC ENGINEERING STUDY MAY BE PERFORMED TO EVALUATE OTHER MEANS TO PROTECT THE CROSSING SUCH AS OVERSIZE SIGNS, OR A PEDESTRIAN ACTUATED TRAFFIC SIGNAL.

** "ALL YEAR" PLAQUE SS1-1 SHALL BE USED AT YEAR-ROUND SCHOOLS ONLY.

SHEET A3

TYPICAL INTERSECTION SCHOOL CROSSWALK – TWO-WAY STOP-CONTROLLED



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TYPICAL INTERSECTION
SCHOOL CROSSWALK
TWO-WAY STOP-CONTROLLED

PROJECT NUMBER APPENDIX A

COUNTY

SHEET NO. A3

SIGNING AND STRIPING PLACEMENT

	POSTED SPEED LIMIT (MPH)	SCHOOL ADVANCE (S1-1) (d)	NO PARKING ZONE LENGTH AT X WALK OR SCHOOL ADVANCE	NO PARKING ZONE LENGTH AFTER X WALK W ≤ 50′	NO PARKING ZONE LENGTH AFTER X WALK 50′ < W ≤ 70′	NO PARKING ZONE LENGTH AFTER X WALK W > 70′	MINIMUM SOLID WHITE LINE LENGTH
	25	250′	60′	40′	25′	20′	150′
	30	325′	85′	50′	35′	25′	150′
	35	400′	115′	70′	50′	35′	200′
	40	475′	150′	90′	65′	45′	250′
*	45	550′	190′	110′	80′	55′	250′
*	50	625′	230′	140′	100′	70′	250′

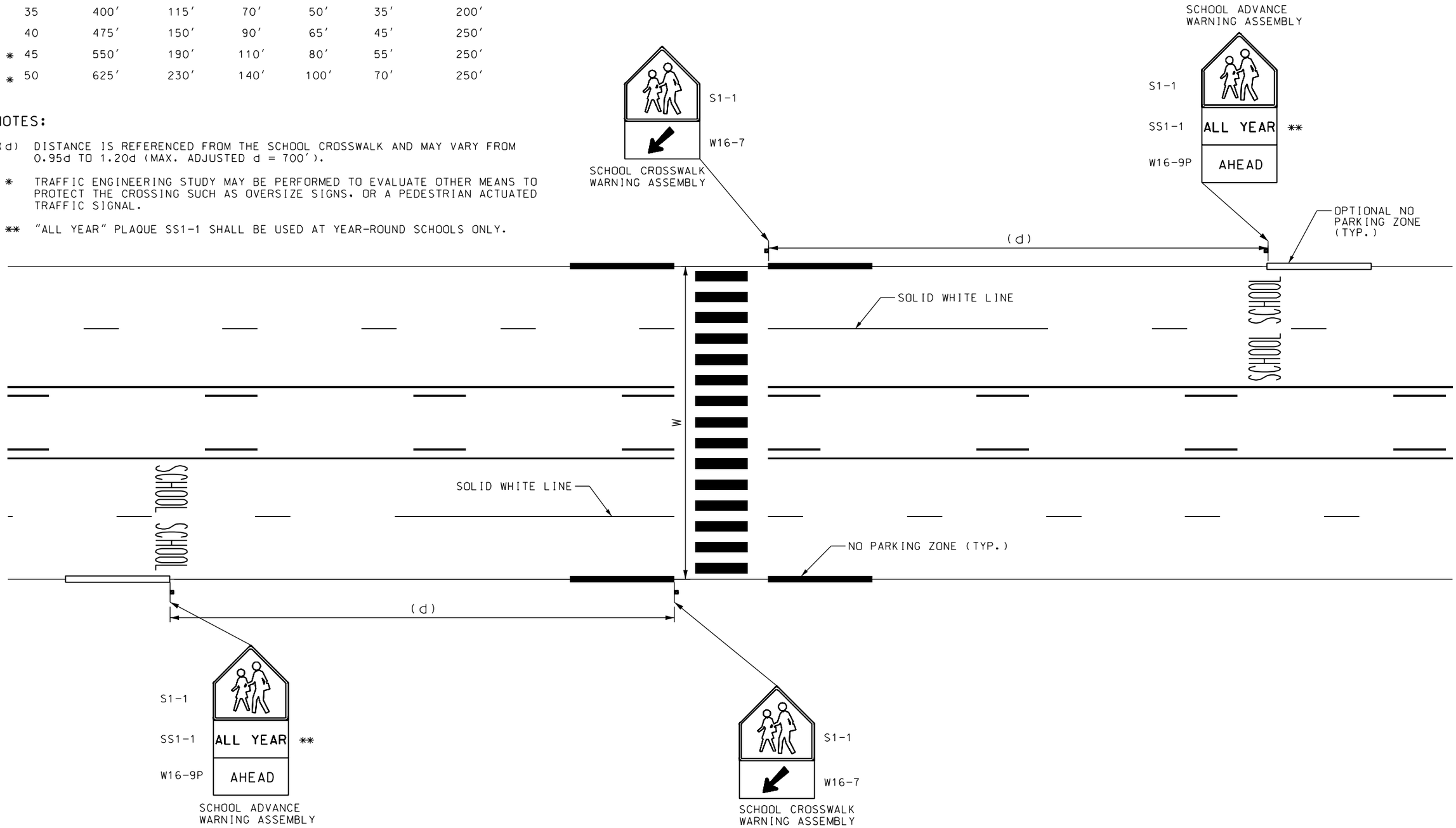
NOTES:

(d) DISTANCE IS REFERENCED FROM THE SCHOOL CROSSWALK AND MAY VARY FROM 0.95d TO 1.20d (MAX. ADJUSTED d = 700′).

* TRAFFIC ENGINEERING STUDY MAY BE PERFORMED TO EVALUATE OTHER MEANS TO PROTECT THE CROSSING SUCH AS OVERSIZE SIGNS, OR A PEDESTRIAN ACTUATED TRAFFIC SIGNAL.

** "ALL YEAR" PLAQUE SS1-1 SHALL BE USED AT YEAR-ROUND SCHOOLS ONLY.

SHEET A4
TYPICAL MIDBLOCK SCHOOL CROSSWALK



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TYPICAL MIDBLOCK SCHOOL CROSSWALK

APPENDIX A

PROJECT NUMBER

COUNTY

SHEET NO. A4

SIGNING AND STRIPING PLACEMENT

POSTED SPEED LIMIT (MPH)	SCHOOL SPEED LIMIT (S5-1) (d1)	SCHOOL ADVANCE (S1-1) (d2)	REDUCED SPEED AHEAD (S2-5a) (d3)	NO PARKING ZONE LENGTH AT X WALK, SCHOOL ADVANCE, OR S5-1	NO PARKING ZONE LENGTH AFTER X WALK W ≤ 50′	NO PARKING ZONE LENGTH AFTER X WALK 50′ < W ≤ 70′	NO PARKING ZONE LENGTH AFTER X WALK W > 70′	MINIMUN SOLID WHITE LINE LENGTH
25	150′	100′	100′	60′	40′	25′	20′	150′
30	150′	100′	130′	85′	50′	35′	25′	150′
35	200′	175′	215′	115′	70′	50′	35′	200′
40	250′	250′	340′	150′	90′	65′	45′	250′
* 45	250′	300′	500′	190′	110′	80′	55′	250′
* 50	250′	400′	640′	230′	140′	100′	70′	250′

NOTES:

(d1) DISTANCE IS REFERENCED FROM THE CROSSWALK AND MAY VARY FROM 0.95d1 TO 1.20d1. (MAX. d1 + d2 = 700′).

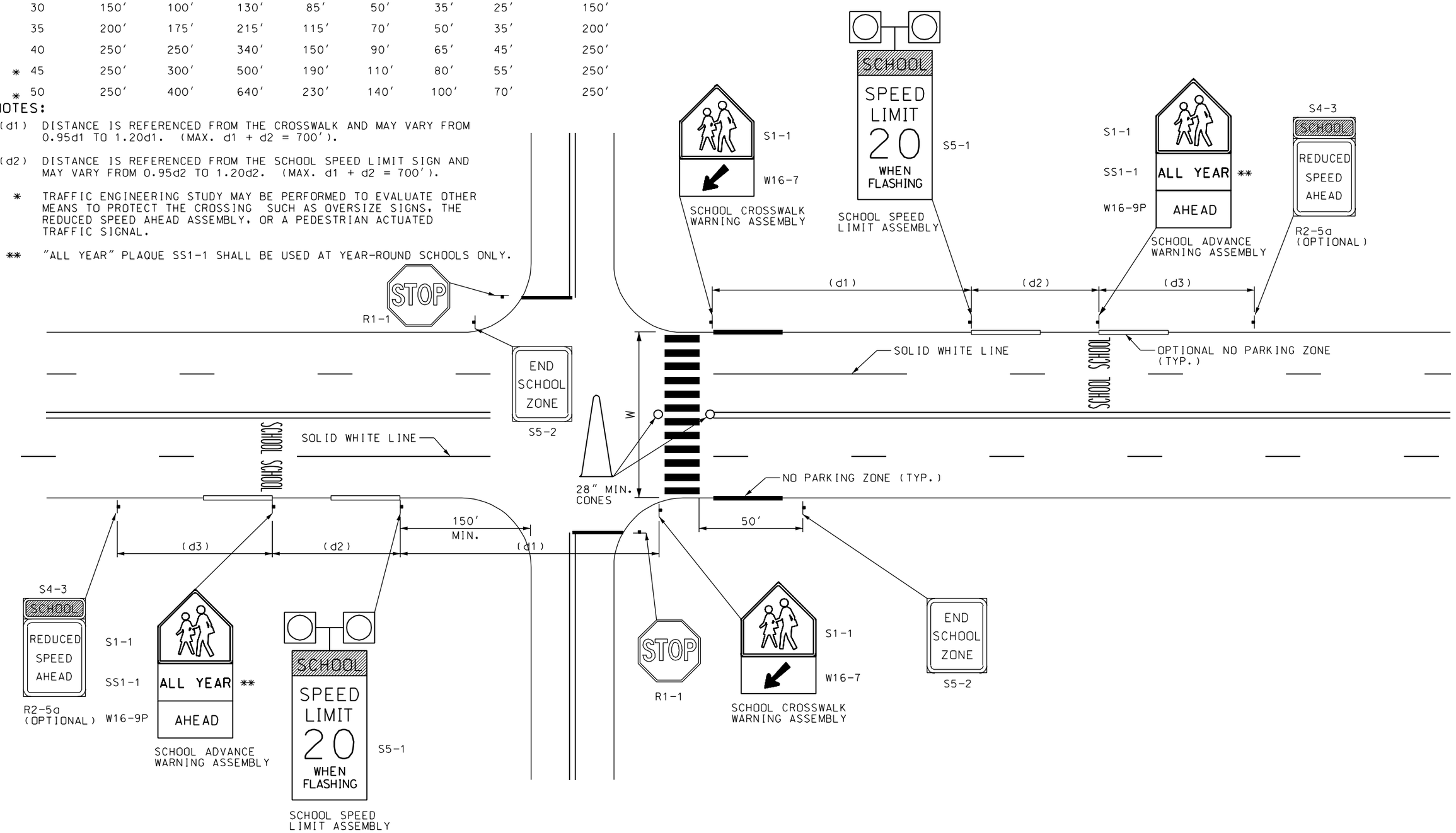
(d2) DISTANCE IS REFERENCED FROM THE SCHOOL SPEED LIMIT SIGN AND MAY VARY FROM 0.95d2 TO 1.20d2. (MAX. d1 + d2 = 700′).

* TRAFFIC ENGINEERING STUDY MAY BE PERFORMED TO EVALUATE OTHER MEANS TO PROTECT THE CROSSING SUCH AS OVERSIZE SIGNS, THE REDUCED SPEED AHEAD ASSEMBLY, OR A PEDESTRIAN ACTUATED TRAFFIC SIGNAL.

** "ALL YEAR" PLAQUE SS1-1 SHALL BE USED AT YEAR-ROUND SCHOOLS ONLY.

SHEET A5

TYPICAL INTERSECTION REDUCED SPEED SCHOOL ZONE - TWO-WAY STOP-CONTROLLED



NO.	DATE	REMARKS
	DESIGN REV.BY	MAPS CORR.BY
		PARCELS AFFECTED
		REQUEST BY
		ORIGINAL SUBMISSION FOR AUTHORIZATION
	DATE	REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
DIVISION OF TRAFFIC AND SAFETY, DESIGN

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BY

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QUANT.
CHECK RJC 07/03
CHECK

APPROVAL RECOMM.
DATE
PROJECT DESIGN ENGINEER
APPROVED
DATE
PRECONSTRUCTION ENGINEER

TYPICAL INTERSECTION
REDUCED SPEED SCHOOL ZONE
TWO-WAY STOP-CONTROLLED

PROJECT NUMBER
APPENDIX A

COUNTY

SHEET NO. A5

$$date$$
$$files$$

SIGNING AND STRIPING PLACEMENT

	POSTED SPEED LIMIT (MPH)	SCHOOL SPEED LIMIT (S5-1) (d1)	SCHOOL ADVANCE (S1-1) (d2)	NO PARKING ZONE LENGTH AT X WALK, SCHOOL ADVANCE, OR S5-1	NO PARKING ZONE LENGTH AFTER X WALK W ≤ 50′	NO PARKING ZONE LENGTH AFTER X WALK 50′ < W ≤ 70′	NO PARKING ZONE LENGTH AFTER X WALK W > 70′	MINIMUM SOLID WHITE LINE LENGTH
	25	150′	100′	60′	40′	25′	20′	150′
	30	150′	100′	85′	50′	35′	25′	150′
	35	200′	175′	115′	70′	50′	35′	200′
	40	250′	250′	150′	90′	65′	45′	250′
*	45	250′	300′	190′	110′	80′	55′	250′
*	50	250′	400′	230′	140′	100′	70′	250′

NOTES:

(d1) DISTANCE IS REFERENCED FROM THE CROSSWALK AND MAY VARY FROM 0.95d1 TO 1.20d1. (MAX. d1 + d2 = 700′).

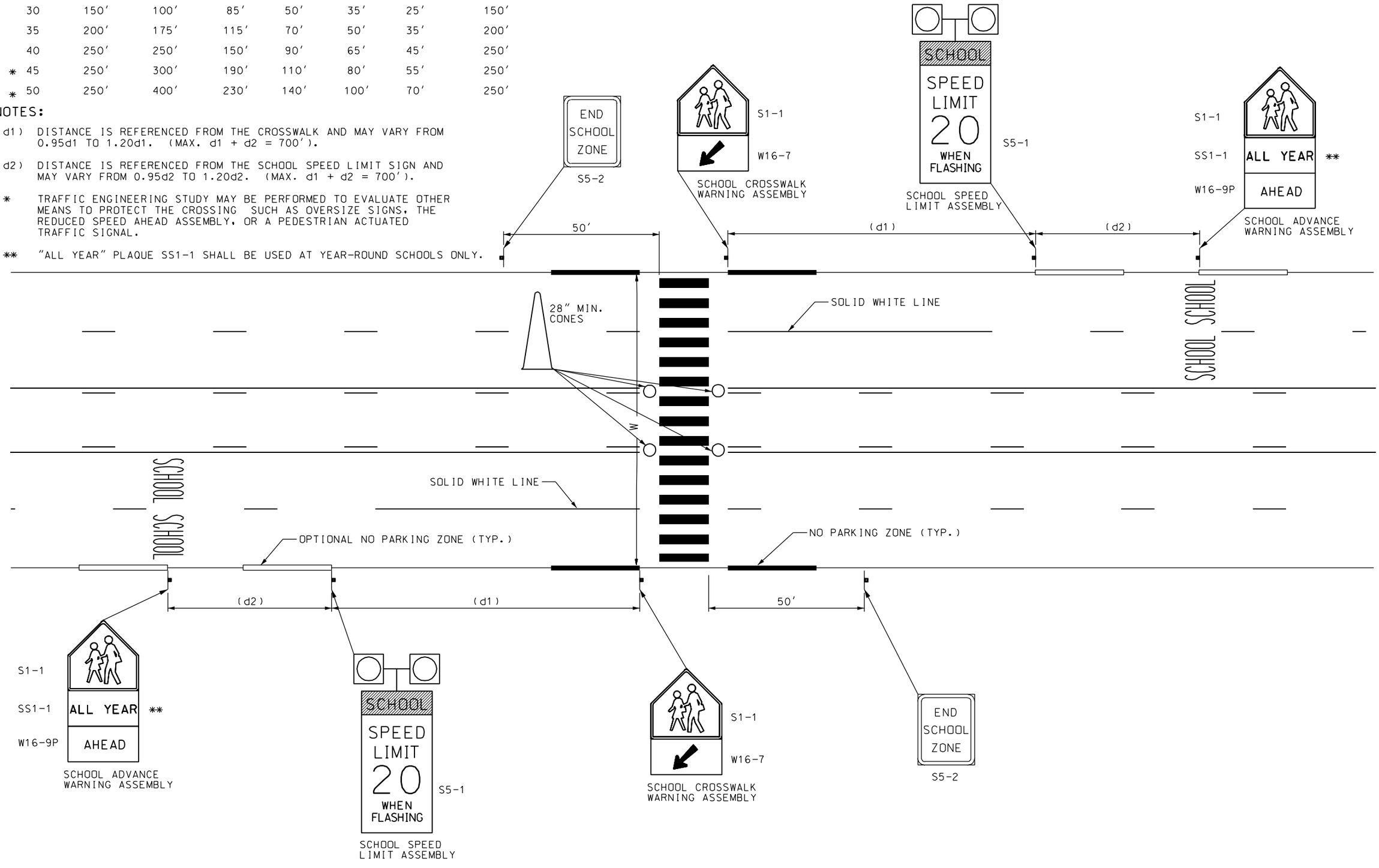
(d2) DISTANCE IS REFERENCED FROM THE SCHOOL SPEED LIMIT SIGN AND MAY VARY FROM 0.95d2 TO 1.20d2. (MAX. d1 + d2 = 700′).

* TRAFFIC ENGINEERING STUDY MAY BE PERFORMED TO EVALUATE OTHER MEANS TO PROTECT THE CROSSING SUCH AS OVERSIZE SIGNS, THE REDUCED SPEED AHEAD ASSEMBLY, OR A PEDESTRIAN ACTUATED TRAFFIC SIGNAL.

** "ALL YEAR" PLAQUE SS1-1 SHALL BE USED AT YEAR-ROUND SCHOOLS ONLY.

SHEET A6

TYPICAL MIDBLOCK REDUCED SPEED SCHOOL ZONE



UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
DIVISION OF TRAFFIC AND SAFETY, DESIGN

REVISIONS

NO.	DATE	REMARKS
		ORIGINAL SUBMISSION FOR AUTHORIZATION
		DESIGN MAPS, PARCELS, REQUEST RECOMM. CORR. BY AFFECTED BY

DESIGN | DRAWN RCC 07/03 | QUANT. | CHECK | CHECK RJC 07/03 | CHECK | REVIEW | DATE | BY

APPROVAL RECOMM. DATE | PROJECT DESIGN ENGINEER
APPROVED DATE | PRECONSTRUCTION ENGINEER

TYPICAL MIDBLOCK REDUCED SPEED SCHOOL ZONE

APPENDIX A

PROJECT NUMBER

COUNTY

SHEET NO. A6

$$file$$

$$date$$

SIGNING AND STRIPING PLACEMENT

	POSTED SPEED LIMIT (MPH)	SCHOOL SPEED LIMIT (S5-1) (d1)	SCHOOL ADVANCE (S1-1) (d2)	NO PARKING ZONE LENGTH AT X WALK, SCHOOL ADVANCE, OR S5-1	AFTER X WALK W ≤ 50′	AFTER X WALK 50′ < W ≤ 70′	AFTER X WALK W > 70′	MINIMUM SOLID WHITE LINE LENGTH
	25	150′	100′	60′	40′	25′	20′	150′
	30	150′	100′	85′	50′	35′	25′	150′
	35	200′	175′	115′	70′	50′	35′	200′
	40	250′	250′	150′	90′	65′	45′	250′
*	45	250′	300′	190′	110′	80′	55′	250′
*	50	250′	400′	230′	140′	100′	70′	250′

NOTES:

(d1) DISTANCE IS REFERENCED FROM THE STOP LINE AND MAY VARY FROM 0.95d1 TO 1.20d1. HOWEVER, THE DISTANCE FROM THE SCHOOL ADVANCE WARNING TO THE SCHOOL CROSSWALK SHALL NOT EXCEED 700′.

(d2) DISTANCE IS REFERENCED FROM THE SCHOOL SPEED LIMIT SIGN AND MAY VARY FROM 0.95d2 TO 1.20d2. HOWEVER, THE DISTANCE FROM THE SCHOOL ADVANCE WARNING TO THE SCHOOL CROSSWALK SHALL NOT EXCEED 700′.

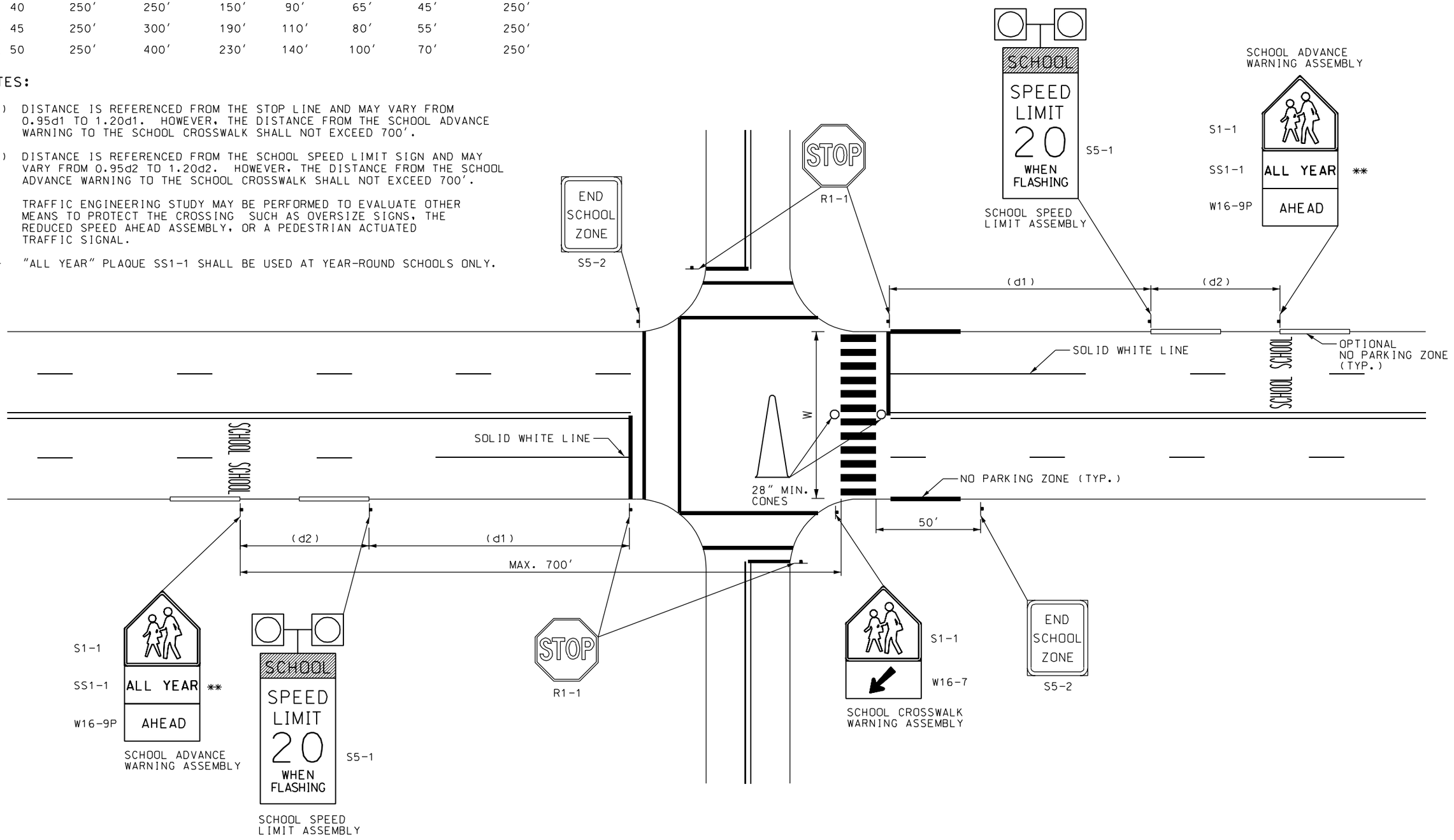
* TRAFFIC ENGINEERING STUDY MAY BE PERFORMED TO EVALUATE OTHER MEANS TO PROTECT THE CROSSING SUCH AS OVERSIZE SIGNS, THE REDUCED SPEED AHEAD ASSEMBLY, OR A PEDESTRIAN ACTUATED TRAFFIC SIGNAL.

** "ALL YEAR" PLAQUE SS1-1 SHALL BE USED AT YEAR-ROUND SCHOOLS ONLY.

SHEET A7

TYPICAL INTERSECTION REDUCED SPEED SCHOOL ZONE - FOUR-WAY STOP-CONTROLLED (FWSC)

(SEE SECTION 7A.03 FOR SPECIAL CONDITIONS FOR USE WITH FWSC)



NO.	DATE	REVISIONS	REMARKS
		DESIGN MAPS, REQUEST RECEIVED CORR. BY AFFECTED BY	
		ORIGINAL SUBMISSION FOR AUTHORIZATION	

UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
DIVISION OF TRAFFIC AND SAFETY, DESIGN

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DESIGN
DRAWN RCC 07/03
QUANT.
APPROVAL RECOMM. DATE PROJECT DESIGN ENGINEER
APPROVED FOR USE BY UDOT DATE PRECONSTRUCTION ENGINEER

TYPICAL INTERSECTION
REDUCED SPEED SCHOOL ZONE
FOUR-WAY STOP-CONTROLLED

PROJECT NUMBER APPENDIX A

COUNTY

SHEET NO. A7

SIGNING AND STRIPING PLACEMENT

	POSTED SPEED LIMIT (MPH)	SCHOOL SPEED LIMIT (S5-1) (d1) ***	SCHOOL ADVANCE (S1-1) (d2)	REDUCED SPEED AHEAD (S2-5a) (d3)	NO PARKING ZONE LENGTH AT X WALK, SCHOOL ADVANCED, OR S5-1	AFTER X WALK W ≤ 50′	AFTER X WALK 50′ < W ≤ 70′	AFTER X WALK W > 70′	MINIMUM SOLID WHITE LINE LENGTH
	25	150′	100′	100′	60′	40′	25′	20′	150′
	30	150′	100′	130′	85′	50′	35′	25′	150′
	35	200′	175′	215′	115′	70′	50′	35′	200′
	40	250′	250′	340′	150′	90′	65′	45′	250′
*	45	250′	300′	500′	190′	110′	80′	55′	250′
*	50	250′	400′	640′	230′	140′	100′	70′	250′

NOTES:

(d1) DISTANCE IS REFERENCED FROM THE CROSSWALK AND MAY VARY FROM 0.95d1 TO 1.20d1. HOWEVER, THE DISTANCE FROM THE SCHOOL WARNING TO THE SCHOOL CROSSWALK SHALL NOT EXCEED 700′.

(d2) DISTANCE IS REFERENCED FROM THE SCHOOL SPEED LIMIT SIGN AND MAY VARY FROM 0.95d2 TO 1.20d2. HOWEVER, THE DISTANCE FROM THE SCHOOL ADVANCE WARNING TO THE SCHOOL CROSSWALK SHALL NOT EXCEED 700′.

* TRAFFIC ENGINEERING STUDY MAY BE PERFORMED TO EVALUATE OTHER MEANS TO PROTECT THE CROSSING SUCH AS OVERSIZE SIGNS, THE REDUCED SPEED AHEAD ASSEMBLY, OR A PEDESTRIAN ACTUATED TRAFFIC SIGNAL.

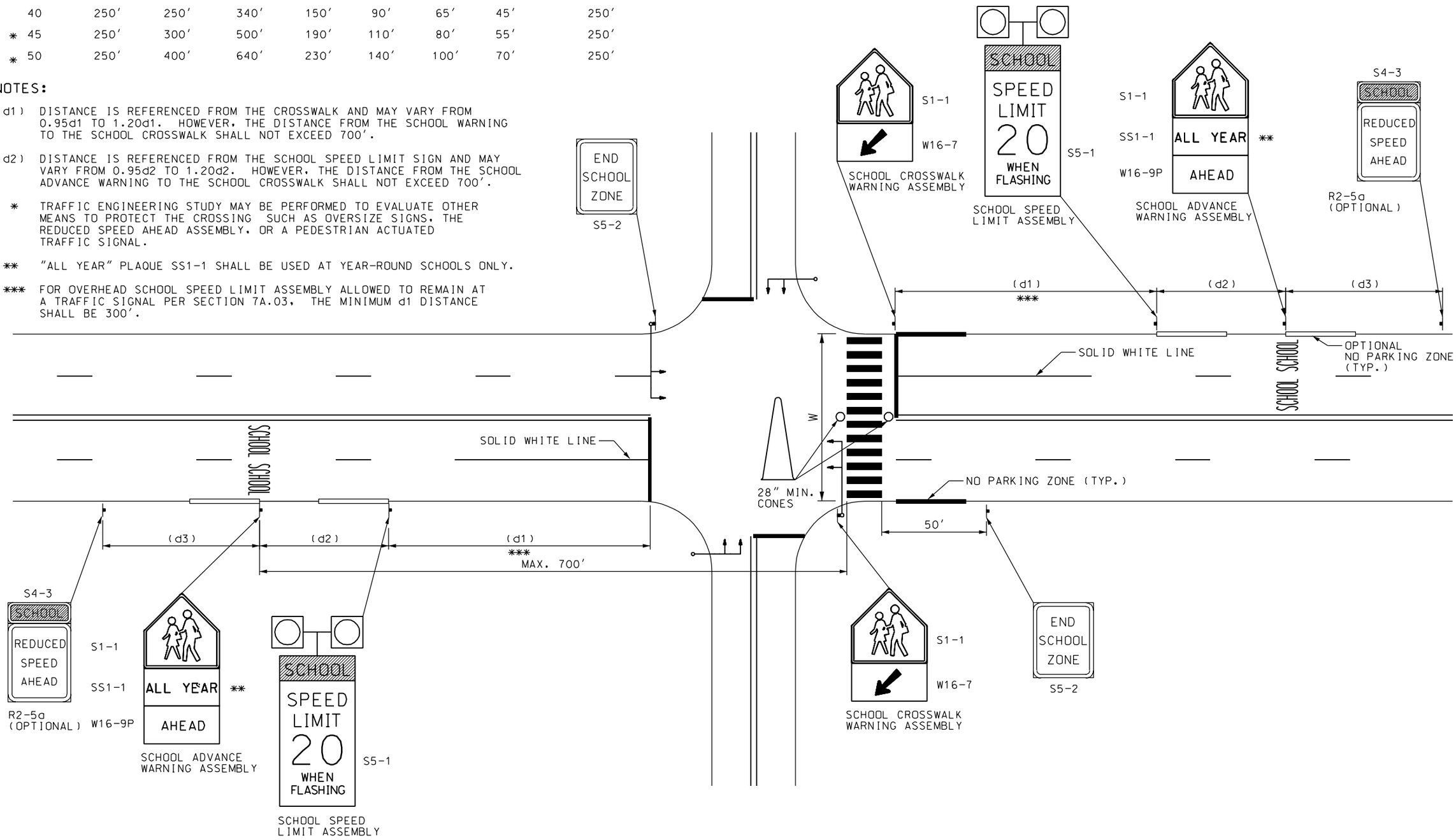
** "ALL YEAR" PLAQUE SS1-1 SHALL BE USED AT YEAR-ROUND SCHOOLS ONLY.

*** FOR OVERHEAD SCHOOL SPEED LIMIT ASSEMBLY ALLOWED TO REMAIN AT A TRAFFIC SIGNAL PER SECTION 7A.03, THE MINIMUM d1 DISTANCE SHALL BE 300′.

SHEET A8

TYPICAL INTERSECTION REDUCED SPEED SCHOOL ZONE - SIGNAL-CONTROLLED

(SEE SECTION 7A.03 FOR SPECIAL CONDITIONS FOR USE AT SIGNALS)



UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
DIVISION OF TRAFFIC AND SAFETY, DESIGN

REVISIONS

NO.	DATE	DESIGN MAPS, PARCELS AFFECTED	REQUEST RELEASED/CONFIRMED BY	REMARKS
				ORIGINAL SUBMISSION FOR AUTHORIZATION

	REVIEW	CHECK	RJC 07/03	CHECK		CHECK	
DATE		DESIGN		DRAWN	RCC 07/03	QUANT.	
BY							

APPROVAL RECOMM. — PROJECT DESIGN ENGINEER — DATE

APPROVED — PRECONSTRUCTION ENGINEER — DATE

TYPICAL INTERSECTION
REDUCED SPEED SCHOOL ZONE
SIGNAL-CONTROLLED

PROJECT NUMBER APPENDIX A

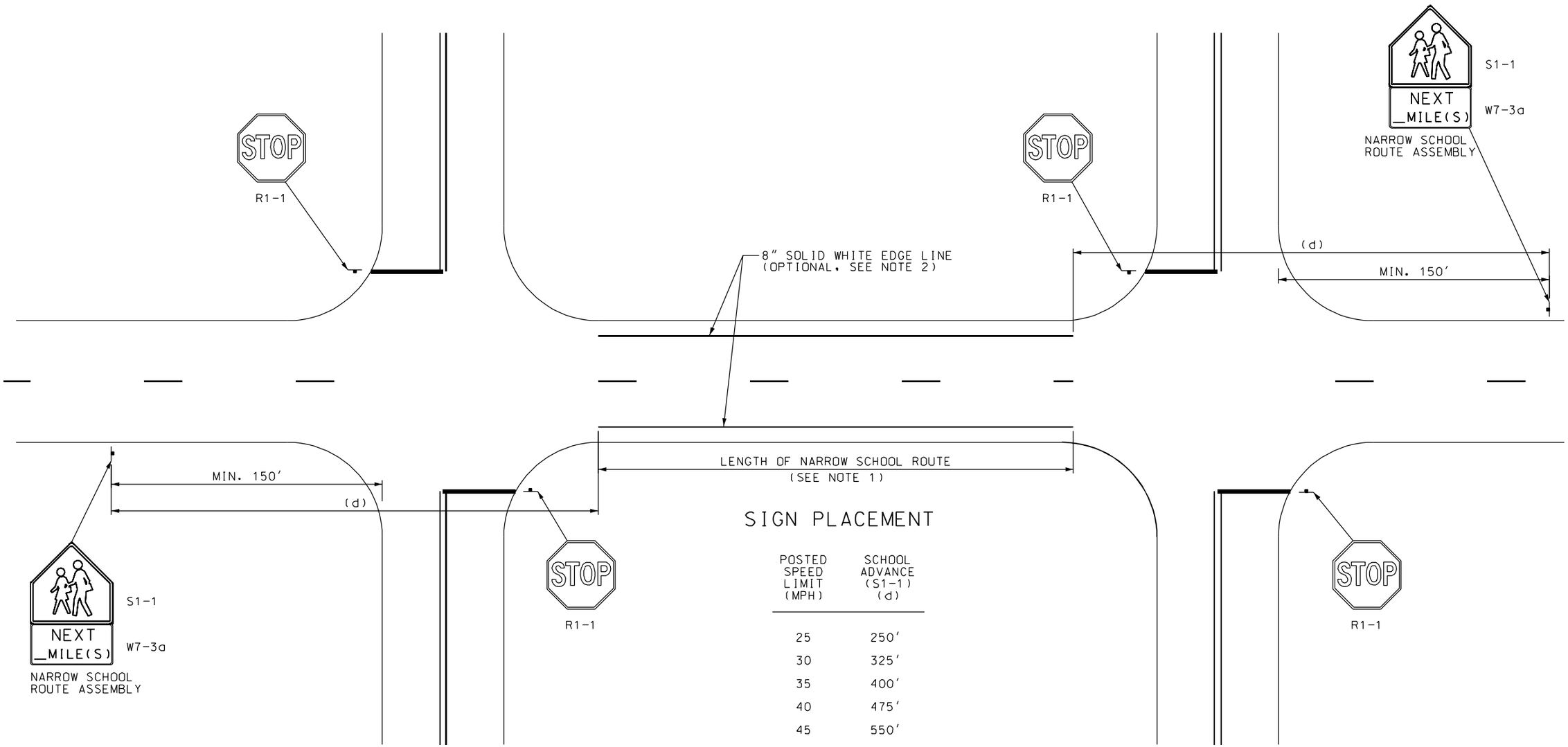
COUNTY

SHEET NO. A8

$$date$$ $$file$$

SHEET A9

TYPICAL NARROW SCHOOL ROUTE



SIGN PLACEMENT

POSTED SPEED LIMIT (MPH)	SCHOOL ADVANCE (S1-1) (d)
25	250'
30	325'
35	400'
40	475'
45	550'
50	625'

NOTES:

(d) DISTANCE IS REFERENCED FROM THE BEGINNING OF THE NARROW SCHOOL ROUTE AND MAY VARY FROM 0.95d TO 1.20d.

(1) THE NARROW SCHOOL ROUTE SHALL NOT BE LONGER THAN 1 MILE IN URBAN AREAS AND 2 MILES IN RURAL AREAS.

(2) ONLY THE SIDE(S) WHICH HAVE SCHOOL CHILDREN WALKING IN A SAFE ROUTING PLAN MAY BE SIGNED AND HAVE THE 8 INCH SOLID WHITE STRIPE.

(3) SIGNS SHALL BE SPACED NO CLOSER TOGETHER THAN 1/4 MILE ALONG THE ROUTE IN URBAN AREAS AND 1/2 MILE IN RURAL AREAS.

REVISIONS

NO.	DATE	DESIGN EXCEPTION APPROVED BY	MAPS CORRECTED BY	PARCELS REVISED BY	REQUEST BY	REMARKS
						ORIGINAL SUBMISSION FOR AUTHORIZATION

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SALT LAKE CITY, UTAH
DIVISION OF TRAFFIC AND SAFETY, DESIGN

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CHECK	DATE	BY

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DRAWN RCC 07/03 CHECK RJC 07/03 CHECK
QUANT. CHECK

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APPROVED DATE PRECONSTRUCTION ENGINEER

TYPICAL NARROW SCHOOL ROUTE

PROJECT NUMBER APPENDIX A

COUNTY

SHEET NO. A9

SIGNING AND STRIPING PLACEMENT

	POSTED SPEED LIMIT (MPH)	SCHOOL ADVANCE (S1-1) (d)	NO PARKING ZONE LENGTH AT SCHOOL ADVANCE
	25	250′	60′
	30	325′	85′
	35	400′	115′
	40	475′	150′
*	45	550′	190′
*	50	625′	230′

NOTES:

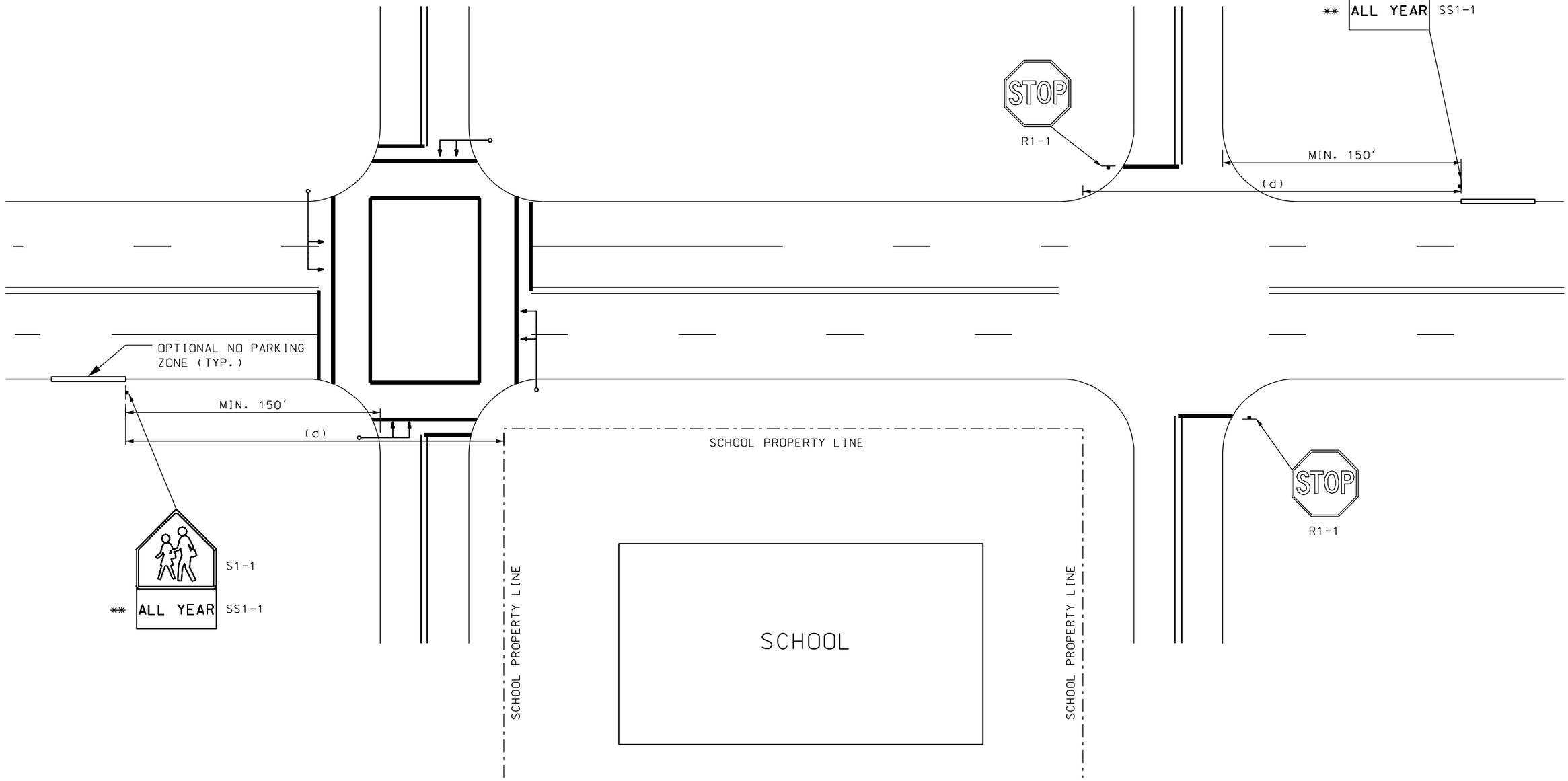
(d) DISTANCE IS REFERENCED FROM THE SCHOOL PROPERTY LINE AND MAY VARY FROM 0.95d TO 1.20d (MAX. ADJUSTED d = 700′).

* TRAFFIC ENGINEERING STUDY MAY BE PERFORMED TO EVALUATE OTHER MEANS TO PROTECT THE CROSSING SUCH AS OVERSIZE SIGNS, OR A PEDESTRIAN ACTUATED TRAFFIC SIGNAL.

** "ALL YEAR" PLAQUE SS1-1 SHALL BE USED AT YEAR-ROUND SCHOOLS ONLY.

SHEET A10

TYPICAL ABUTTING SCHOOL ZONE (OPTIONAL)



NO.	DATE	DESIGN REV. BY	MAPS CORR. BY	PARCELS AFFECTED	REQUEST BY	REMARKS
	DATE	ORIGINAL SUBMISSION FOR AUTHORIZATION				

REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
SALT LAKE CITY, UTAH
DIVISION OF TRAFFIC AND SAFETY, DESIGN

REVIEW

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DRAWN RCC 07/03 CHECK RJC 07/03
QUANT. CHECK

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APPROVED DATE PRECONSTRUCTION ENGINEER

TYPICAL INTERSECTION
SCHOOL ZONE (OPTIONAL)

PROJECT NUMBER APPENDIX A

COUNTY

SHEET NO. A10

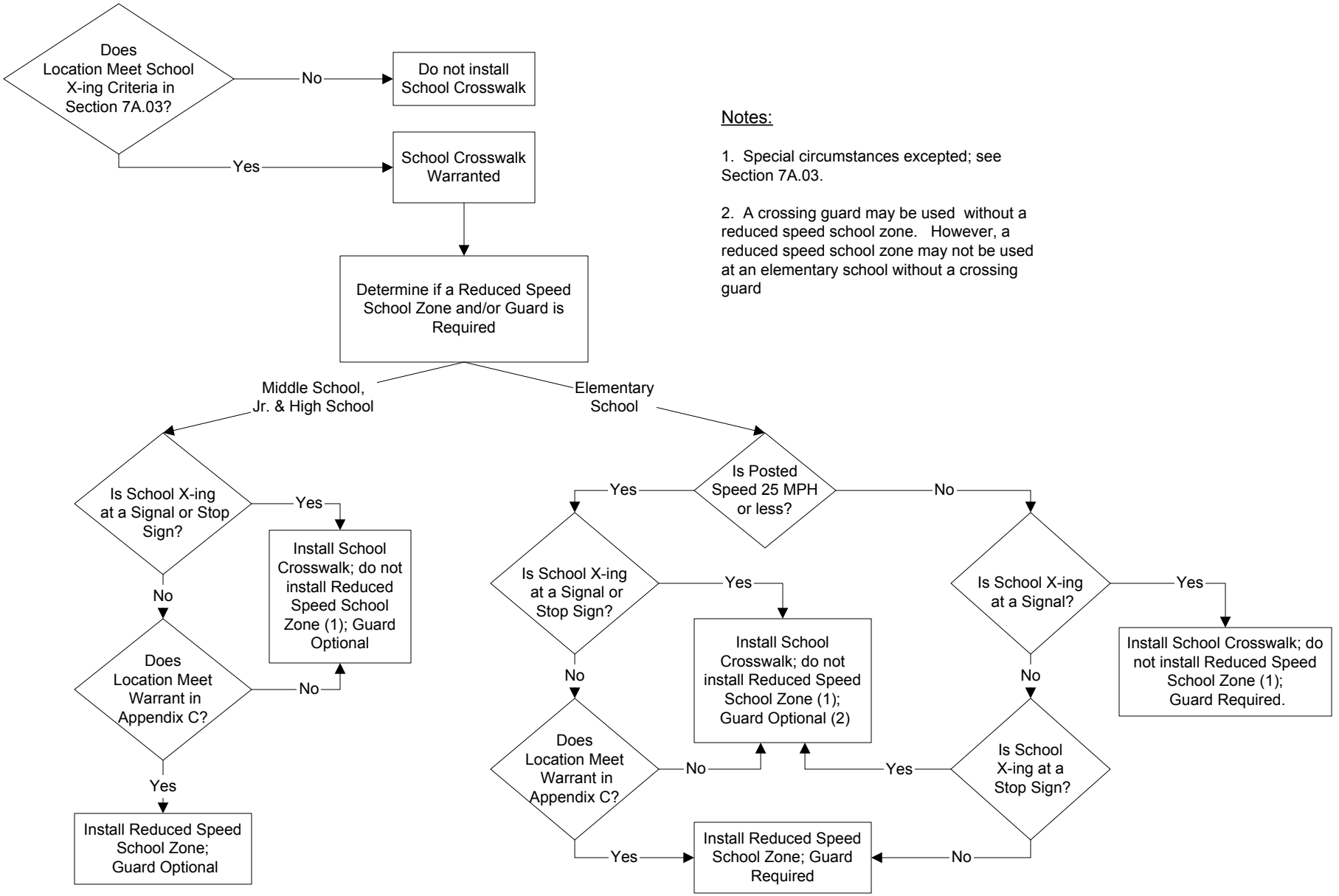
$$file$$
$$date$$

APPENDIX B

School Zone Protection Flowcharts

Appendix B1

Requirements for School Crosswalks, Reduced Speed School Zones and Crossing Guards.



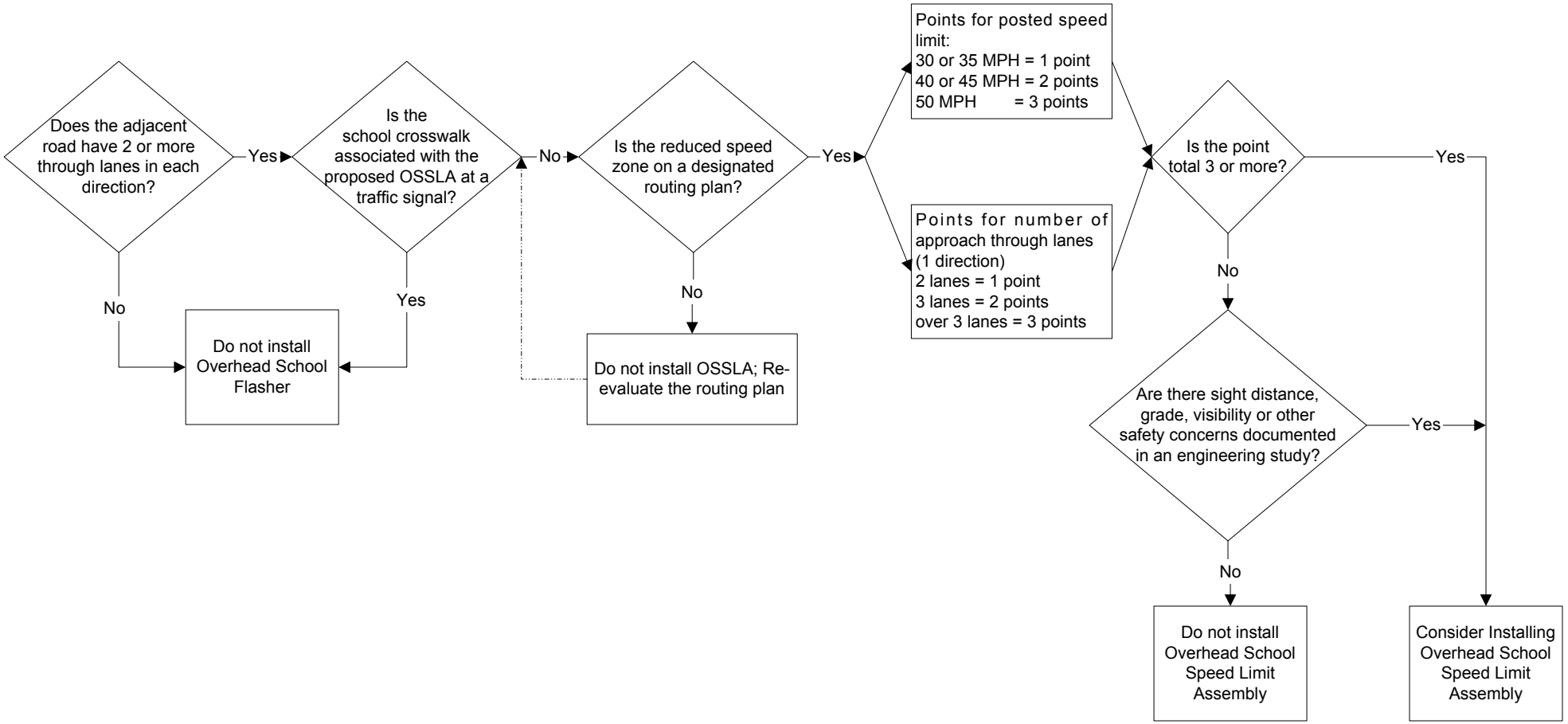
Notes:

1. Special circumstances excepted; see Section 7A.03.

2. A crossing guard may be used without a reduced speed school zone. However, a reduced speed school zone may not be used at an elementary school without a crossing guard

Appendix B2

Requirements for an Overhead School Speed Limit Assembly (OSSLA) in a Reduced Speed School Zone.



APPENDIX C

Warrant: Reduced Speed School Zone

WARRANT:
REDUCED SPEED SCHOOL ZONE

Minimum points required for a Reduced Speed School Zone is 16 in an urban area, or 12 for an isolated rural community of under 10,000 population.

CATEGORIES

Average Time Between Useable Gaps	Maximum 10 Points
School Pedestrian Volume	Maximum 10 Points
85th Percentile Approach Speed	Maximum 5 Points
Average Demand Per Gap	Maximum 8 Points

A Reduced Speed School Zone **shall not** be installed under any of the following conditions:

1. The school pedestrian volume is 10 or less.
2. The posted approach speed exceeds 50 mph.
3. Minimum Stopping Sight Distance for the Crosswalk is less than that defined in the most recent edition of A Policy on Geometric Design of Highways and Streets, AASHTO.

DEFINITIONS:

1. **School Pedestrian Volume** - Includes all children between ages 5 and 18 that use the school crossing.

2. **Evaluation Period (EP)** - From forty-five (45) minutes before school starts in the morning until fifteen (15) minutes after school starts or from fifteen (15) minutes before school adjourns until forty-five (45) minutes after school ends.

3. **Minimum Usable Gap Time (MUGT)** - The minimum gap in traffic required for a single or group of school pedestrians to safely cross a given street width, determined as follows:

$$MUGT = \frac{W}{3.0} + 5.0 = \text{crossing time in seconds}$$

where:
W = pavement width in feet
3.0 = juvenile pedestrian walking speed in feet/second
5.0 = perception, reaction, and clearance time

4. **Total Usable Gap (G)** - The summation of Usable Gaps during the Evaluation Period. A Usable Gap is any gap in traffic equal to or greater than the Minimum Usable Gap Time (MUGT).

5. **Maximum Number of Usable Gaps (MNUG)** - Ratio of Total Usable Gap Time to Minimum Usable Gap Time during the Evaluation Period.

$$MNUG = \frac{G}{MUGT} = \frac{Total\ Usable\ Gap\ Time\ during\ EP\ (Seconds)}{Minimum\ Usable\ Gap\ Time\ (Seconds)}$$

6. **A "Demand"** - The arrival of one or more school pedestrians at the school crossing. The arrival of a single child is considered one demand. The arrival of a group of children is also considered one demand.

WARRANT

1. Average Time Between Usable Gaps (M)

Determine Average Time between Usable Gaps (M) by dividing EVALUATION PERIOD (EP, minutes) by the Maximum Number of Usable Gaps (MNUG).

$$M = \frac{EP}{MNUG} = \frac{Evaluation\ Period\ (Minutes)}{Maximum\ Number\ of\ UsableGaps}$$

POINT ASSIGNMENT	
Average Time Between Usable Gaps (minutes)	**Points**
Less than 1	0
1.00 - 1.25	2
1.26 - 1.67	4
1.68 - 2.50	6
2.51 - 5.00	8
Over 5	10

Maximum 10

2. School Pedestrian volume

Determine total number of school pedestrians (age 5 to 18) crossing at the study location during the EVALUATION PERIOD.

POINT ASSIGNMENT		
Urban	**Rural**	**Points**
10 or less	10 or less	0
11 - 30	11 - 20	2
31 - 50	21 - 35	4
51 - 70	36 - 50	6
71 - 90	51 - 65	8
Over 90	Over 65	10

Maximum 10

3. 85th percentile approach Speed

POINT ASSIGNMENT	
Approach Speed	**Points**
20 and under	0
21 - 25	1
26 - 30	2
31 - 35	3
36 - 40	4
41 - 45	5
Over 45	0

Maximum 5

4. Average Demand Per Gap (D)

Determine average demand per gap (D) by dividing total demands (TD) by the maximum number of usable gaps (MNUG). The arrival of a single child is considered one demand. The arrival of a group of children is also considered one demand.

$$D = \frac{TD}{MNUG}$$

POINT ASSIGNMENT	
Average Demand Per Gap	**Points**
1 or less	0
1.01 - 1.67	2
1.68 - 2.33	4
2.34 - 3.00	6
Over 3.00	8

Maximum 8

After point values are determined for steps 1 through 4, the sum of steps 1 through 4 are compared to the following standard to determine if a reduced speed school zone is warranted:

1. Minimum 16 points in an urban area; or,
2. Minimum 12 points in an isolated, rural community with population under 10,000.

SURVEY METHODS

1. Personnel Requirements: One person
2. Equipment: Stop Watch and Field Data Form
3. Type of Survey:

a. Count school-age pedestrians within the Crosswalk area during the Evaluation Period (EP) to determine the School Pedestrian Volume. The Evaluation Period may be either in the morning or in the afternoon.

b. Obtain the 85^{th} percentile approach speed. If the 85^{th} percentile approach speed is unknown, the posted speed limit can be used.

c. Record (in seconds), on the field data form, each gap greater than or equal to the Minimum Usable Gap Time (MUGT) during the Evaluation Period.

d. Record, on the field data form, the Average Time between Usable Gaps (M), the school age pedestrian volume, the approach speed, and the Average Demand per Gap (D).

e. Evaluate the individual warrants, assign points, and tabulate points to determine if a reduced school speed zone is justified.

UTAH DEPARTMENT OF TRANSPORTATION

DIVISION OF TRAFFIC AND SAFETY

REDUCED SPEED SCHOOL ZONE WARRANT EVALUATION WORK SHEET

ROUTE:_____ MP:_____ INTERSECTION:_____ COMMUNITY:_____

DATE:_____ BEGIN TIME:_____ WEATHER:_____

DISTRICT:_____ END TIME:_____ INVESTIGATOR:_____

1. MINIMUM USABLE GAP TIME

$$\frac{\text{WIDTH OF STREET (W)}}{\text{3.0 FT / SEC}} + 5.0 = \frac{\quad}{3.0} + 5.0$$

2. MAXIMUM NO. OF USABLE GAPS (MNUG)

$$\frac{\textit{TOTAL}\text{ USABLE GAP TIME DURING EP (SEC)}}{\textit{MINIMUM}\text{ USABLE GAP TIME (SEC)}} = \quad$$

3. AVERAGE DEMANDS PER GAP (D)

$$\frac{\textit{TOTAL}\text{ DEMANDS DURING EP (TD)}}{\textit{MINIMUM}\text{ NO. USABLE GAPS (MNUG)}} = \quad$$

4. AVERAGE TIME BETWEEN USABLE GAPS (M)

$$\frac{\text{EVALUATION PERIOD (MIN)}}{\text{MAXIMUM NO. OF USABLE GAPS (MNUG)}} = \quad$$

WARRANT	ACTUAL VALUE	ASSIGNED POINTS	MAXIMUM POINTS
1. AVERAGE TIME BETWEEN GAPS (M)			10
2. SCHOOL PEDESTRIAN VOLUME (NUMBER)			10
3. 85TH PERCENTILE APPROACH SPEED (MPH)			5
4. AVERAGE DEMAND PER GAP (D)			8
		TOTAL	**33**

STANDARD (URBAN) = 16

STANDARD (Rural, isolated, population < 10,000) = 12

WARRANTED? (Yes/No)

SKETCH

USABLE GAP TIMES FOR SCHOOL PEDESTRIAN VOLUME									
TIME	USABLE GAP TIME (Sec)	TIME	USABLE GAP TIME (Sec)	TIME	USABLE GAP TIME (Sec)	TIME	USABLE GAP TIME (Sec)	TIME	USABLE GAP TIME (Sec)
Subtotal		Subtotal		Subtotal		Subtotal		Subtotal	

Total Usable Gap Time during EP = _____ Seconds (summation of the subtotals)

SCHOOL PEDESTRIAN VOLUME AND DEMAND TALLY (Five Minute Intervals for 60 Minutes)									
	Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	Interval 6	Interval 7	Interval 8	Interval 9
PEDS									
DEMANDS									
	Interval 10	Interval 11	Interval 12	**Remarks:**					
PEDS									
DEMANDS									

APPENDIX D

Utah Department of Transportation
Contact Information
and Region Map

Utah Department of Transportation
Contact Information

UDOT Region 1
169 North Wall Avenue
PO Box 12580
Ogden, UT 84412-2580
(801) 620-1600

UDOT Region 2
2010 South 2760 West
Salt Lake City, UT 84104-4592
(801) 975-4900

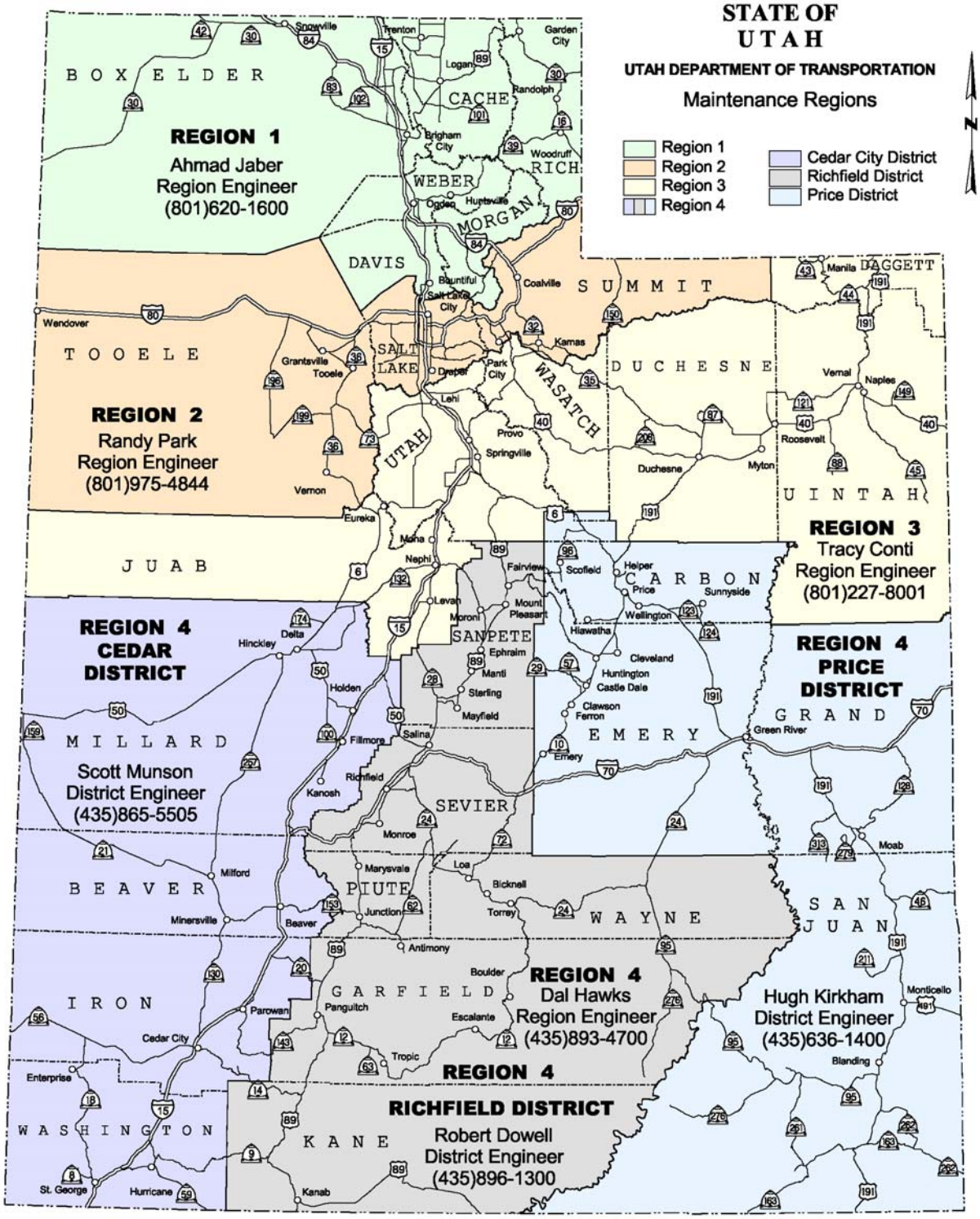
UDOT Region 3
658 North 1500 West
Orem, UT 84057
(801) 227-8000

UDOT Region 4
1345 South 350 West
Richfield, UT 84701
(435) 893-4799

Chief RR and Utilities Engineer
Utah Department of Transportation
Project Development Division
4501 South 2700 West
Box 148445
Salt Lake City, UT 84114-8445
(801) 965-4176

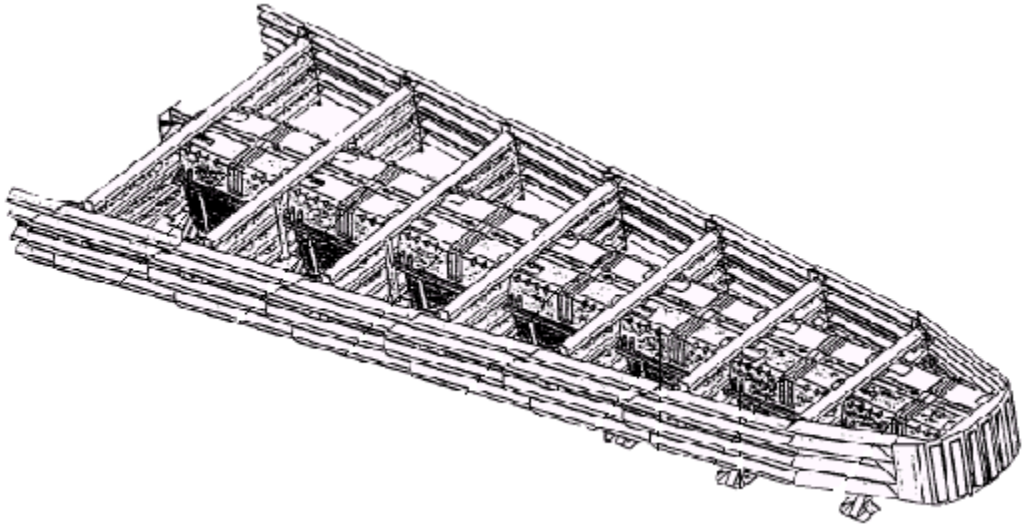
Engineer for Traffic and Safety
Utah Department of Transportation
Traffic and Safety Division
4501 South 2700 West
Box 143200
Salt Lake City, UT 84114-3200
(801) 965-4273

Note:
UDOT Region Map on next page


STATE OF
UTAH
UTAH DEPARTMENT OF TRANSPORTATION
Maintenance Regions
Region 1
Region 2
Region 3
Region 4
Cedar City District
Richfield District
Price District
N
REGION 1
Ahmad Jaber
Region Engineer
(801)620-1600
REGION 2
Randy Park
Region Engineer
(801)975-4844
REGION 3
Tracy Conti
Region Engineer
(801)227-8001
REGION 4
CEDAR
DISTRICT
Scott Munson
District Engineer
(435)865-5505
REGION 4
PRICE
DISTRICT
REGION 4
Dal Hawks
Region Engineer
(435)893-4700
REGION 4
RICHFIELD DISTRICT
Robert Dowell
District Engineer
(435)896-1300
Hugh Kirkham
District Engineer
(435)636-1400
BOX ELDER
CACHE
RICH
WEBER
MORGAN
DAVIS
SUMMIT
DAGGETT
TOOELE
SALT LAKE
WASATCH
DUCHESNE
UINTAH
UTAH
JUAB
SANPETE
CARBON
MILLARD
SEVIER
EMERY
GRAND
BEAVER
PIUTE
WAYNE
SAN JUAN
IRON
GARFIELD
KANE
WASHINGTON
Snowville
Trenton
Garden City
Logan
Randolph
Brigham City
Woodruff
Ogden
Huntsville
Bountiful
Salt Lake City
Coalville
Manila
Wendover
Grantsville
Tooele
Kamas
Park City
Draper
Lehi
Provo
Springville
Vernal
Naples
Roosevelt
Duchesne
Myton
Vernon
Eureka
Nephi
Fairview
Scofield
Helper
Price
Sunnyside
Levan
Mount Pleasant
Wellington
Moroni
Hiawatha
Ephraim
Manti
Cleveland
Huntington
Castle Dale
Sterling
Mayfield
Clawson
Ferron
Emery
Green River
Delta
Hinckley
Holden
Fillmore
Salina
Richfield
Kanosh
Monroe
Moab
Milford
Marysvale
Loa
Bicknell
Minersville
Beaver
Junction
Torrey
Antimony
Boulder
Parowan
Panguitch
Escalante
Cedar City
Tropic
Enterprise
St. George
Hurricane
Kanab
Monticello
Blanding

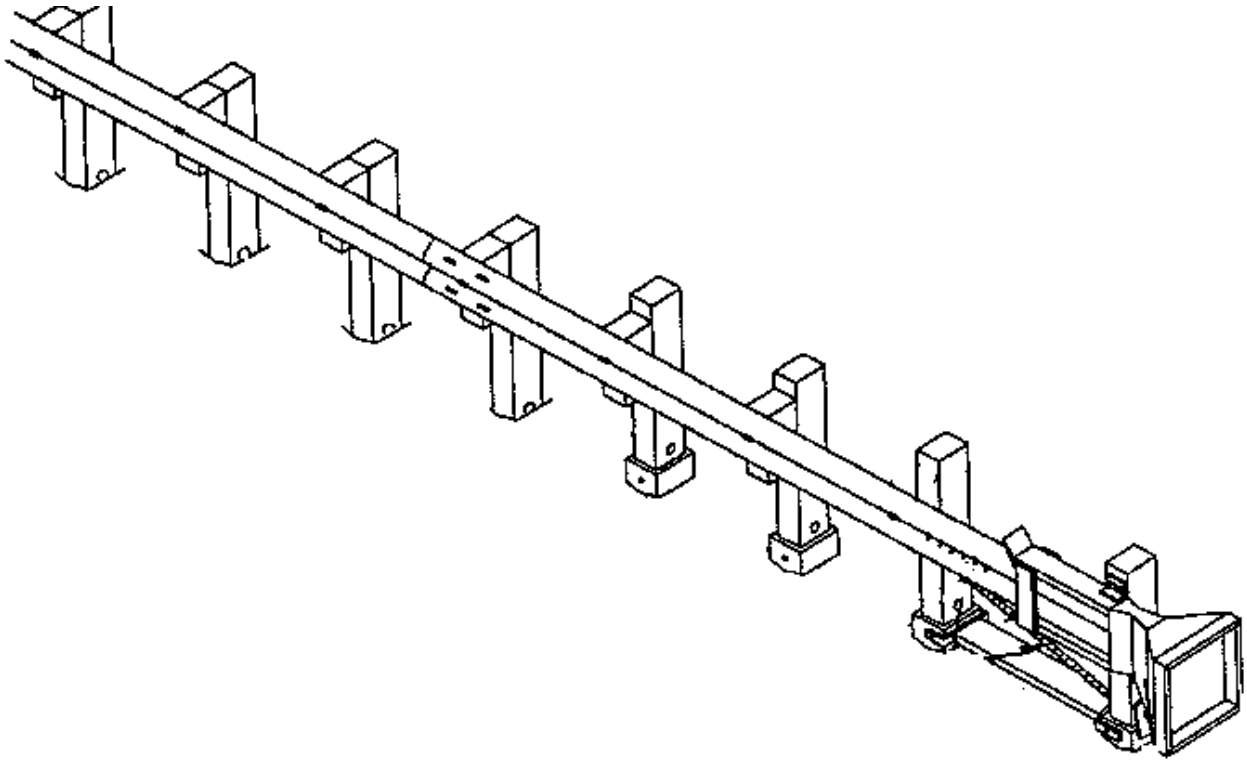
Barriers and Attenuators

UTAH DEPARTMENT OF TRANSPORTATION



Guidelines for

CRASH CUSHIONS



UTAH DEPARTMENT OF TRANSPORTATION

GUIDELINES FOR

CRASH CUSHIONS

&

APPROVED PRODUCTS LIST

PREPARED BY THE DIVISION OF TRAFFIC & SAFETY

DATED **MAY 1, 2003**

TABLE OF CONTENTS

UDOT GUIDELINES FOR CRASH CUSHIONS

INTRODUCTION

May 1, 2003

UDOT has adopted NCHRP 350 testing Basic TL-3 as the standard for crash cushions. Testing is done using a minimum of two types of production model vehicles, a small car and a pickup truck at a nominal speed of 60 MPH. Each device must pass a minimum number of tests in order to receive FHWA certification as a compliant system. More information about the testing requirements can be found in NCHRP Report 350, Recommended Procedures for the Safety Performance Evaluation of Highway Features. All systems listed in this guide have been approved for use on the State and National Highway Systems.

A designer may designate any one system for a project, when there is a choice of more than one system, but must submit a letter of public interest explaining why this is the preferred system. The letter will be sent to the Traffic & Safety Operations Engineer, Division of Traffic & Safety. The Traffic & Safety Operations Engineer will forward it, with recommendation, to the Federal Highway Administration for approval. The approved letter will be placed in the project file.

These guidelines will list the type of crash cushion, a brief description, and application of the system.

The Crash Cushion Type with the manufacturer's name and the local supplier will identify each system.

Systems identified as construction zone systems will not be used in a permanent application without prior approval from the Traffic & Safety Operations Engineer, Division of Traffic & Safety.

Each approved crash cushion will have the following information:

NCHRP Test Level: the level a system has passed NCHRP 350 testing.

TL-1 $\leq$ 40 MPH
TL-2 $\geq$ 45 MPH and $\leq$ 55 MPH
TL-3 > 55 MPH

Crash Cushion Types A, B, D and E can be configured to meet varying design criteria. Types C, F, G and H are all TL-3 systems.

LON: Length Of Need indicates that portion of the system that can be included as part of the barrier LON requirement.

Characteristics: the manner in which the system has been designed to perform.

Application: a statement that lists some of the appropriate uses, requirements and Standard Drawings applicable to the system.

Requirements: conditions needed to insure proper operation of the system. Special requirements may be needed to handle drainage, or specific grading requirements for the systems. If there are special circumstance or requirement contact the Traffic & Safety Operations Engineer.

Offset: (guardrail approved systems) the distance from the traveled way to the system.

SYSTEM TYPES & DESCRIPTION

Summary Table of Approved Crash Cushions For Permanent Application

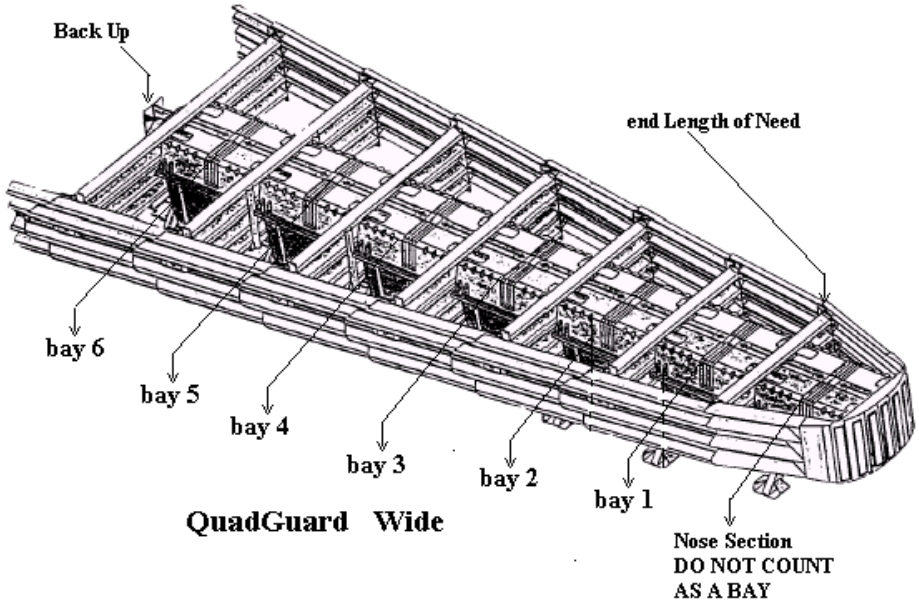
CRASH CUSHIONS		
Type A: Primarily to protect wide fixed hazards with limited recovery area, non gating system		
Name	Manufacturer	NCHRP Test Level
Quad Guard Wide	Energy Absorption Systems	TL-1, TL-2, Tl-3
Type B: Primarily to protect narrow fixed hazards with limited recovery area, non gating system		
Name	Manufacturer	NCHRP Test Level
Quad Guard	Energy Absorption Systems	TL-1, TL-2, TL-3
Type C: Primarily to protect narrow hazards with available recovery area, gating system		
Name	Manufacturer	NCHRP Test Level
Brakemaster 350	Energy Absorption Systems	TL-3
CAT 350	Trinity Industries, Inc.	TL-3
Type D: Primarily to protect hazards with limited recovery area and high potential of impact, non gating system		
	Manufacturer	NCHRP Test Level
Quad Guard Elite	Energy Absorption Systems	TL-2, TL-3
Quad Guard LMC	Energy Absorption Systems	TL-3
REACT 350	Roadway Safety Service Inc.	TL-2, TL-3
Type E: Primarily to protect hazards a minimum of 15 feet from travel lane with available recovery area, gating system		
Name	Manufacturer	NCHRP Test Level
Sand Barrels "Big Sandy" Energite III Fitch Barrel	 TrafFix Devices Inc. Energy Absorption Systems Roadway Safety Services Inc.	TL-1, TL-2, TL-3
Type F: Primarily to protect concrete barrier ends and bridge parapets with limited longitudinal space and available recovery area, gating system.		
Name	Manufacturer	NCHRP Test Level
Quad Trend 350	Energy Absorption Systems	TL-3
Type G: Primarily to protect guardrail approach ends on tangent guardrail installations with available recovery area, can be used to protect concrete barrier ends and bridge parapets when a transition element is used, gating system.		
Name	Manufacturer	NCHRP Test Level
ET 2000 / ET PLUS	Trinity Industries, Inc.	TL-3
SKT 350	Road Systems Inc.	TL-3
Type H: Primarily to protect guardrail approach ends on tangent or flared guardrail installations with available recovery area, can be used to protect concrete barrier ends and bridge parapet when a transition element is used, gating system.		
Name	Manufacturer	NCHRP Test Level
FLEAT 350	Road Systems Inc	TL-3
SRT 350 8 Post System	Trinity Industries, Inc.	TL-3
SRT/ HBA 6-Post System	Trinity Industries, Inc.	TL-3

TYPE A (1 approved system)

To protect fixed hazards greater than 60 inches wide within 15 feet of the traveled way, with less than 100 feet of longitudinal space in front of the hazard and a recover area behind the system is unattainable. Use to protect concrete barrier ends, bridge parapets or piers, and other hazards as a stand-alone system. A transition element is required to protect single or double-faced guardrail ends. These systems may be used on shoulders or in medians where a recovery area behind system and hazard is unattainable. These systems should be used in areas where minimal impacts are anticipated, one impact every three or more years.

Name: QuadGuard® Wide from Energy Absorption Systems

www.energyabsorption.com/products/permanent/quadguard_cen.htm



Length

Varies according to speed requirements, see NCHRP test level below

Width

2 standard widths: 69 inches and 90 inches

NCHRP Test Level

TL-1, ≤ 40 mph	2 bay, length	8' 9"
TL-2, 45 mph	3 bay, length	11' 9"
TL-2, 50 mph	4 bay, length	14' 9"
TL-2, 55 mph	5 bay, length	17' 9"
TL-3, > 55 mph	6 bay, length	20' 9" ***see note***

Note: The manufacturer's design manual for this system list more bays for higher levels of speed. However these systems exceed the requirements set by FHWA and are not required for use. A six bay system is all that is required for speeds greater than 55 mph.

Length of Need

From rear of nose section

Characteristics

Re-directive, bi-directional, unidirectional, non-gating, non-pocketing.
System is equipped with two types of Hex Foam cartridges that absorb energy from an impacting vehicle. The fender panels redirect an impacting vehicle.

This system may be retrofitted to meet the requirements of the Type D, QuadGuard Elite System requirements, when repair history indicates a benefit would be realized.

Application

For fixed objects within 15 feet of the traveled lane(s), with a width ranging from 60 inches to a maximum width of 90 inches, where there is less than 100 feet of clear area in front of hazard, and the recovery area on the backside of the system is less than 75 feet x 20 feet.

This system can be used to protect concrete barrier, hazards in gore areas, lighting and sign structures, bridge parapets, piers, and as a stand-alone system. Transition elements are required for use with single and double-faced guardrail.

This system should be used in areas where minimal impacts are anticipated (one impact every three or more years).

Requirements

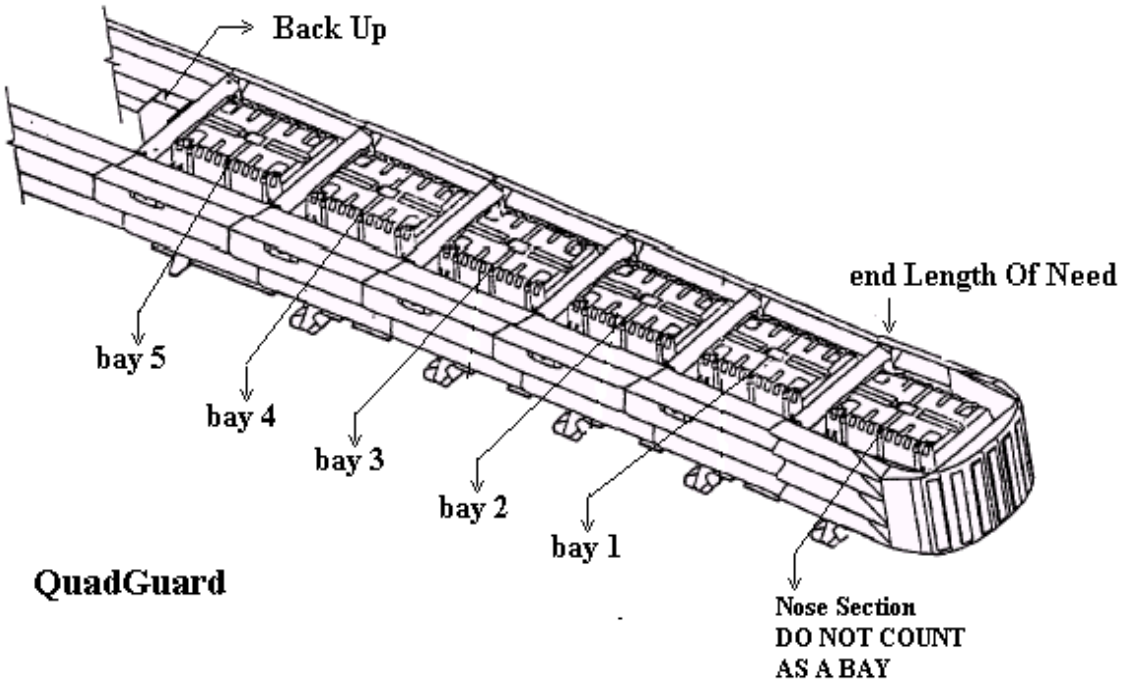
The area in front of the system will have a slope of 10:1 or less and be free of any obstacles for a minimum of 50 feet. The slope to the sides of the system, from any travel lane, will be no greater than 10:1 and be free of any obstacles.

Refer to UDOT STD DWG CC 4. See manufacturer's specifications for pad, backup and transition requirements. See STD DWG CC 2, Plan A2 or STD DWG CC 3 Guideline B, where drainage requirements are needed. It is critical the proper cartridge is in the proper bay. The nose compartment uses a Type I cartridge in all applications. The manufacturer, supplier, or installer of the system will provide the appropriate directional object panel and marker post, UDOT STD. DWG CC 1.

Type B (1 approved system)

To protect fixed hazards less than 3 feet wide within 15 feet of traveled way, with less than 100 feet of longitudinal space in front of the hazard and a recovery area on the backside of the system is unattainable. Use to protect concrete barrier ends, bridge parapets or piers, and other hazards as a stand-alone system. A transition element is required to protect single or double-faced guardrail ends. These systems may be used on shoulders or in medians. These systems should be used in areas where minimal impacts are anticipated (one impact every three or more years).

Name: QuadGuard® from Energy Absorption Systems
www.energyabsorption.com/products/permanent/quadguard_cen.htm



Length: Varies according to speed requirements, see test level below.

Width: Three standard widths: 24 inches, 30 inches and 36 inches

NCHRP Test Level:

TL-2, 45 mph	3 bay, length	11' 9"
TL-2, 50 mph	4 bay, length	14' 9"
TL-2, 55 mph	5 bay, length	17' 9"
TL-3, > 55 mph	6 bay, length	20' 9" ***see note below***

Note: The design manual for this system list more bays for higher levels of speed. However these systems exceed the requirements set by FHWA and are not required for use. A six bay system is all that is required for speeds greater than 55 mph.

Length of Need: Rear of the nose section

Characteristics

Re-directive, bi-directional, unidirectional, non-gating, non-pocketing.
System is equipped with two types of Hex Foam cartridges that absorb energy from an impacting vehicle. The fender panels redirect an impacting vehicle.
This system may be retrofitted to meet the requirements of the Type D, QuadGuard Elite System requirements, when repair history indicates a benefit would be realized.

Application

For fixed objects within 15 feet of the traveled lane(s), with a width ranging from 24 inches to a maximum width of 36 inches, where there is less than 100 feet of clear area in front of hazard and the recovery area behind system is less than 75 feet x 20 feet. The area in front of the system will have a slope of 10:1 or less and be free of any obstacles. The slope to the sides of the system, from any travel lane, will be no greater than 10:1 and be free of any obstacles. Refer to UDOT STD DWG CC 4.

This system can be used to protect concrete barrier, hazards in gore areas, lighting and sign structures, bridge parapets, and piers as a stand-alone system. Transition elements are required for use with single and double-faced guardrail. When used with double-faced guardrail both sides of the system requires the use of two transition pieces attached to both sides of the guardrail runs.
This system should be used in areas where minimal impacts are anticipated (one impact every three or more years).

Requirements

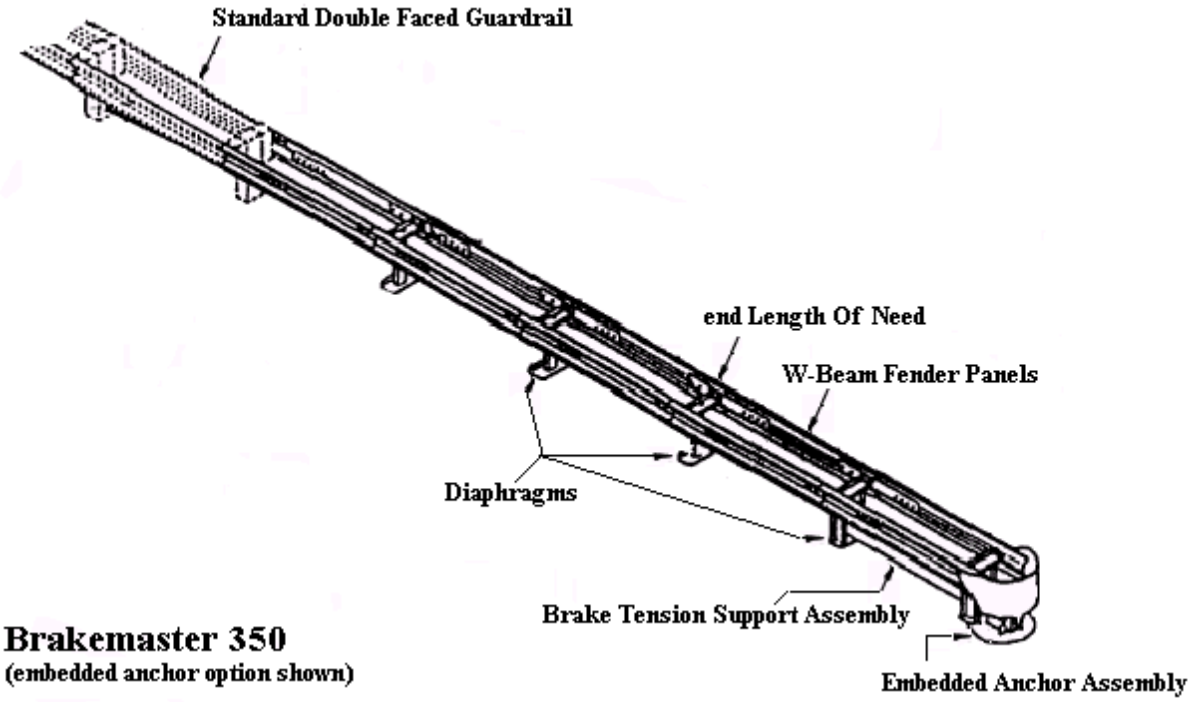
Refer to UDOT STD DWG CC 4 for all grading and placement requirements. See manufacturer's specifications for pad, backup and transition requirements. See STD DWG CC 2, Plan A2 or STD DWG CC 3 Guideline B, where drainage requirements are needed. It is critical the proper cartridge is in the proper bay. The nose compartment uses a Type I cartridge in all **applications.** The manufacturer, supplier, or installer of the system will provide the appropriate directional object panel and marker post, UDOT STD. DWG CC 1.

Type C (2 approved systems)

To protect fixed objects 36 inches wide or less, within 15 feet of traveled way, and with longitudinal space in front of the hazard greater than 100 feet. Primarily used with double-faced guardrail. A transition element is required for concrete barrier or bridge parapet. These systems may be used on shoulders or in medians. Shoulder application requires a recovery area of 75 feet x 20 feet. Median application is required to have a recovery area of no less than 75 feet x 20 feet on both sides of the system. These systems should be used in area where minimal impacts are anticipated (one impact every three or more years).

Name: BRAKEMASTER® 350 from Energy Absorption Systems

www.energyabsorption.com/products/permanent/Brakemaster350System



Brakemaster 350
(embedded anchor option shown)

Length: 31 feet 6 inches

Width: 2 feet 1 inch

Front Anchor Option:

This system is available with an embedded concrete anchor assembly, or a two-foundation tube anchor assembly. Both anchor assemblies are acceptable.

NCHRP Test Level: TL-3, may be used at any speed limit

Length of Need: Starting at diaphragm # 3, 16 feet from front of system

Characteristics

Gating, re-directive, bi-directional, uni-directional. This system rides above the ground and has no post. When this system is impacted head-on the braking system engages controlling the deceleration of the impacting vehicle to dissipate the energy of the impacting vehicle. This system has many parts that can be reused after impact; inspection should be competed prior to ordering replacement parts.

Application:

Shoulder: For fixed objects within 15 feet of the traveled lane and a width 24 inches or less, and where there is a minimum of 100 feet of clear area in front of hazard (150 feet when a transition element required to attach system to bridge parapet or concrete barrier).

Median: To protect fixed objects within 15 feet of the nearest approach lane and have a recovery area of 75 feet x 20 feet available before intrusion into the nearest opposing lane. A 10:1 slope is required, on both sides of the system. May be installed on concrete, asphalt, or soil surfaces. Refer to UDOT STD DWG CC 5.

Requirements

Transition requirements change for concrete barrier and bridge parapet, see manufacturer's specifications for proper transition element. The system attaches directly to single and double-faced guardrail. Refer to manufacturer's installation instructions for front anchor assembly requirements. The approach to the front of the system requires a slope of no greater than 10:1 for a length of 50 feet, and is free of any obstacles. The approach slope from the travel lane(s) to the side(s) of the system is required be no greater than 10:1 and be free of any obstacles. The recovery area behind the system will not be less than 75 feet x 20 feet, and on a slope no greater than 4:1, refer to UDOT STD DWG CC 5. The manufacturer, supplier or installer of the system will provide the appropriate directional object panel and marker post, UDOT STD DWG CC 1.

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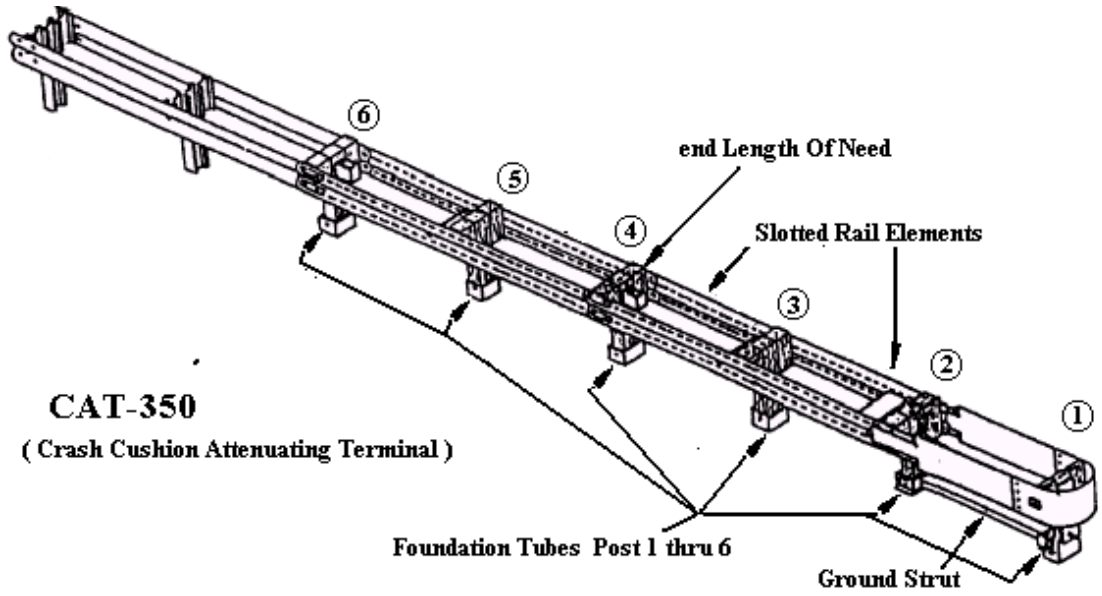
Type C (continued)

Name: C.A.T. 350™ from Syro, Inc., A Trinities Industries Co.
www.highwayguardrail.com



Length: 31 feet 3 inches

Width: 2 feet

NCHRP Test Level: TL-3, may be used at any speed limit

Length of Need: Starting at post # 4, 18 feet 9 inches from front of system

Characteristics

Gating, re-directive, bi-directional, and unidirectional. When this system is impacted head-on the slotted guardrail is forced over pins, which shear the rail. This shearing dissipates the energy of the impact, along with the CRT post. Soil tubes with soil plates required. This is a sacrificial system, many of the components must be replaced after an impact.

Applications

Shoulder: For fixed objects within 15 feet of the traveled lane and a width 24 inches or less and where there is a minimum of 100 feet of clear area in front of hazard (150 feet when a transition element is required to attach system to bridge parapet or concrete barrier). The approach to the front of the system requires a slope of no greater than 10:1 for a length of 50 feet, and free of any obstacles. The approach slope from the travel lane to the side of the system is required be

no greater than 10:1 and be free of any obstacles. The recovery area behind the system will not be less than 75 feet x 20 feet, and on a slope no greater than 4:1.

Median: To protect fixed objects within 15 feet of the nearest approach lane and have a recovery area of 75 feet x 20 feet available before intrusion into the nearest opposing lane. The approach to the front of the system requires a slope of no greater than 10:1 for a length of 50 feet, and free of any obstacles. A 10:1 slope is required, on both sides of the system. May be installed on concrete, asphalt, or soil surfaces. Refer to UDOT STD DWG CC 5.

Requirements

Transition requirements are different for concrete barrier and bridge parapet. See manufacturer's specifications for proper transition element. The system attaches directly to single and double-faced guardrail. The manufacturer, supplier, or installer of the system will provide the appropriate directional object panel and marker post, UDOT STD DWG CC 1.

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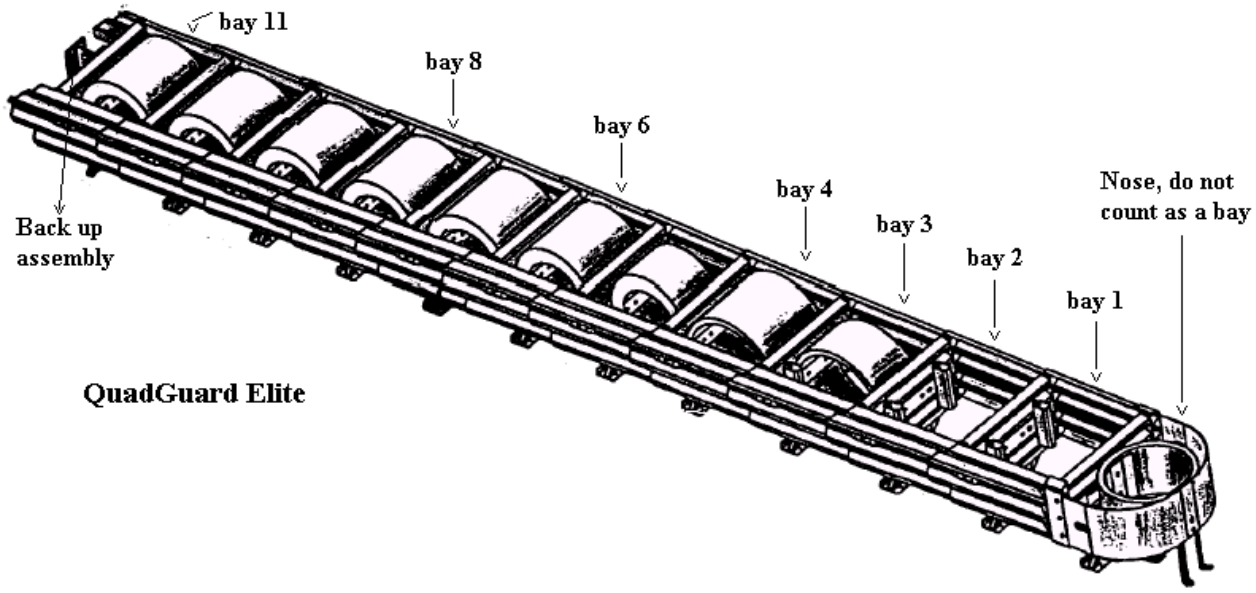
Type D (3 approved systems)

To protect fixed hazards within 15 feet of traveled way, with less than 100 feet of space in front of the hazard. Used to protect concrete barrier ends, bridge parapets or piers, or other hazards as a stand-alone system. A transition element is required for use with single and double face guardrail. These systems may be used on shoulders or in medians. **These systems should be used in areas where more than one impact per year is anticipated or when repair history indicates two or more impacts over a three-year period.**

Name: QuadGuard® ELITE from Energy Absorption Systems
www.energyabsorption.com/products/permanent/QuadGuardEliteSystem.htm



QuadGuard Elite

Length: Varies with speed requirements, see test level below

Width: Five standard widths: 24 inches, 30 inches, 36 inches, 60 inches, and 90 inches. The 60 inch and 90 inch systems flare out on both sides to obtain the required width at backup.

NCHRP Test Level

TL-2, ≤ 45 mph	7 bays, length 21 feet 6 inches
TL-3, > 45 mph	11 bays, length 33 feet 4 inches

Characteristics

Re-directive, bi-directional, unidirectional, non-gating, non-pocketing. This system uses polyethylene cylinders, of varying wall thickness, which compress upon impact absorbing the energy from the impacting vehicle. The cylinders will return to their original shape after system is reset. Bays 1 and 2 do not have

cylinders. The fender panels redirect an impacting vehicle. This system can withstand multiple impacts with minimal repair.

Application

To protect fixed objects within 15 feet of the traveled lane, with width up to 90 inches. The approach to the front of the system will have a slope of 1:10 or less and be clear of any obstructions for a minimum of 50 feet. The approach slopes on either side of the system will be 1:10 or less. Refer to UDOT STD DWG CC 4. This system should be used in areas where at least one impact per year is anticipated, or when repair history indicates two or more impacts over a three-year period.

Requirements

See manufacturer's specifications for pad, backup and transition requirements. See STD DWG CC 2, Plan A2 or STD DWG CC 3 Guideline B, where drainage requirements are needed. The manufacturer, supplier or installer of the system will provide the appropriate directional object panel and marker post, UDOT STD DWG CC 1.

Note: The QuadGuard Elite and QuadGuard LMC are similar in appearance; the difference is the material the cylinders are manufactured with.
The cylinders from the QuadGuard Elite may be used to upgrade the standard QuadGuard systems (Types A and B) when required.

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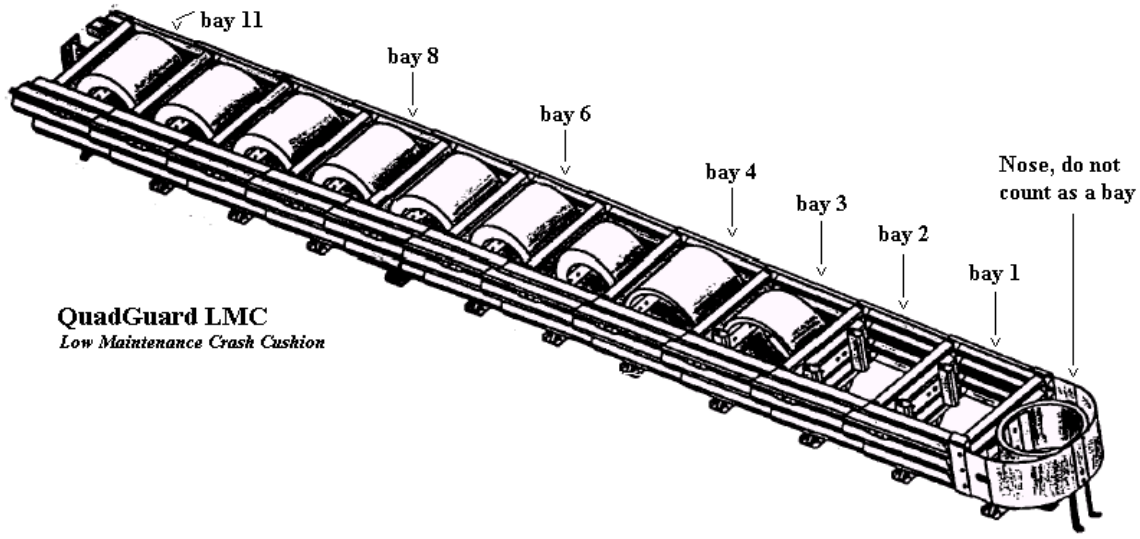
Type D (continued)

Name: * QuadGuard® LMC from Energy Absorption Systems
www.energyabsorption.com/products/permanent/QuadGuardLMCSystem.htm



Length: 31 feet, this system is available in one length only

Width: Three standard widths: 36 inches, 60 inches, and 90". The 60 inch and 90 inch systems flare out on both sides to obtain the required width at backup.

NCHRP Test Level: TL-3, 11 bays (may be used with any speed)

Characteristics

Re-directive, bi-directional, unidirectional, non-gating, non-pocketing. This system uses elastomeric cylinders, of varying wall thickness, which compress upon impact absorbing the energy from the impacting vehicle. The cylinders will return to their original shape after system is reset. Bays 1 and 2 do not have cylinders. The fender panels redirect an impacting vehicle. This system can withstand multiple impacts with minimal repair.

Application

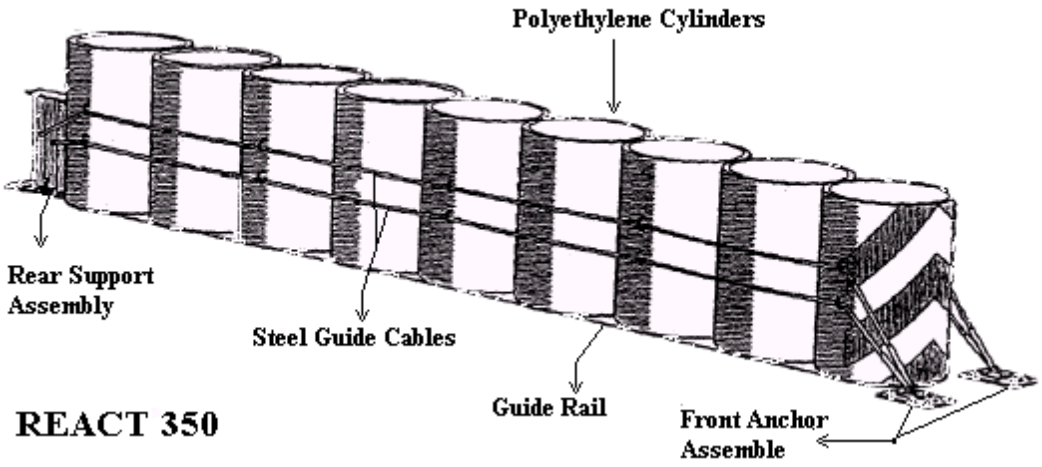
To protect fixed objects within 15 feet of the traveled lane, with widths up to 90 inches. This system should be used in areas where at least one impact per year is anticipated, or when repair history indicates two or more impacts over a three-year period.

Requirements

See manufacturer's specifications for pad, backup and transition requirements. The approach to the front of the system will have a slope of 10:1 or less and be

clear of any obstructions. The approach slopes on either side of the system will be 10:1 or less. Refer to UDOT STD DWG CC 4.
See STD DWG CC 2, Plan A2 or STD DWG CC 3 Guideline B, where drainage requirements are needed. The manufacturer, supplier or installer of the system will provide the appropriate directional object panel and marker post, UDOT STD DWG CC 1.
* Note: The QuadGuard LMC and QuadGuard Elite are similar in appearance, the difference is the material the cylinders are manufactured with.

Name: REACT 350™ from Energy Absorption Systems,
www.energyabsorption.com/products/permanent/React350.htm



Length: Varies to speed requirements, see test level below

Width: 3 feet 11 inches

NCHRP Test Level

TL-2, ≤ 45 mph	4 cylinders, length 15 feet 3 inches
TL-2, ≥ 50 mph	6 cylinders, length 21 feet 3 inches
TL-3, ≥ 60 mph	9 cylinders, length 30 feet 3 inches

Characteristics

Re-directive, bi-directional, unidirectional, non-gating, non-pocketing. This system uses polyethylene cylinders with varying wall thickness, which compress upon impact absorbing the energy from the impacting vehicle. The cylinders will return to approximately 80% of there original shape after impact. The cables used on this system give the system a re-directive capability. This system can withstand multiple impacts with minimal repair.

Application

To protect fixed objects within 15 feet of the traveled lane, with width up to 36 inches. This system should be used in areas where at least one impact per year is anticipated, or when repair history indicates two or more impacts over a three year period.

Requirements

See manufacturer's specifications for pad, backup and transition requirements. . The approach to the front of the system will have a slope of 1:10 or less and be clear of any obstructions. The approach slopes on either side of the system will be 1:10 or less. Refer to UDOT STD DWG CC 4. See STD DWG CC 2, Plan A2 or STD DWG CC 3 Guideline B, where drainage requirements are needed. The manufacturer provides the object marker for this system and a marker post is not required due to the height of the system.

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Type E- Sand Barrel Arrays

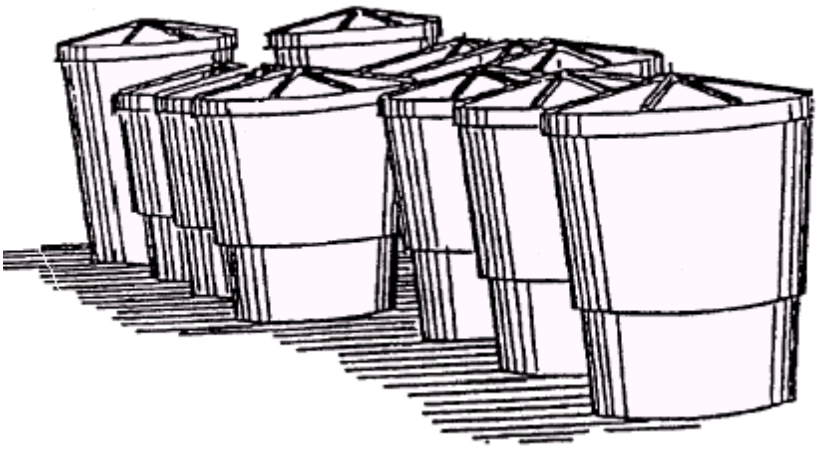
To protect fixed hazards outside 15 feet of the traveled way where there is an unlimited amount of space. This system can be configured to meet varying width requirements. Use to protect concrete barrier ends, bridge parapets or piers, or other hazards as a stand-alone system. This system can be used in a work zone when the hazard being protected meets the 15 foot criteria.

Name: Three approved manufacturers.

1. **"Big Sandy" TrafFix Devices Inc.**
   www.traffixdevices.com

2. **Energite® III Barrels, Energy Absorption Systems**
   www.energyabsorption.com/products/permanent/EnergiteIIISystem.htm

3. **Universal Barrels, Energy Absorption Systems**
   www.energyabsorption.com/products/permanent/UniversalBarrels.htm



Sand Barrels

Length: Variable

Width: Variable

NCHRP Test Level: TL-1, TL-2, TL-3

(Designer to designate speed and width requirements)

Length of Need: Variable

Characteristics

Non-re-directive, uni-directional, bi-directional, gating, pocketing. This system uses plastic container filled with varying amounts of sand, which transfers and dissipates the energy from a impacting vehicle.

Application

Use to protect fixed objects outside 15 feet of the traveled lane.

Requirements

Refer to UDOT STD DWG CC 6 for pad and placement requirements The approach slope to the front of the system will be no greater 20:1 and free any obstacles for a length of 50 feet prior to the first barrel. The approach slope from the travel lanes to the sides of the system application will be no greater than 10:1 and be free of any obstacles. The required recovery area behind the system is 75 feet X 20 feet, and on a slope no greater than 4:1. Use Energite III Design Manual when designing this system (available from Division of Traffic & Safety). The manufacturer, supplier or installer of the system will provide the appropriate directional object panel UDOT STD DWG CC 1.

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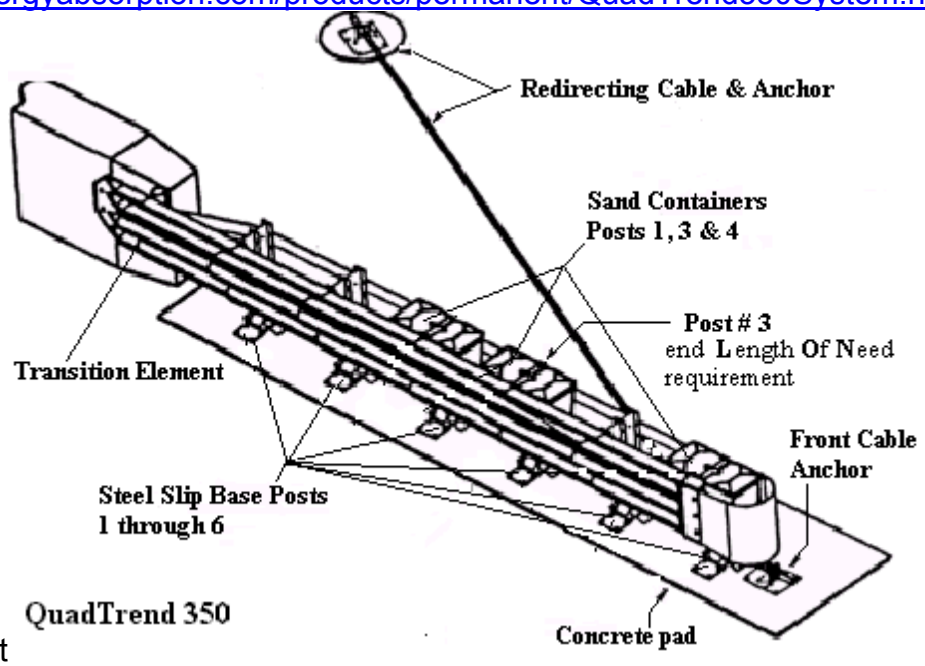
Type F (1 approved system)

Use to protect concrete barrier or bridge parapet with less than 125 feet of longitudinal space in front of hazard.

Name: QuadTrend 350™ from Energy Absorption Systems
www.energyabsorption.com/products/permanent/QuadTrend350System.htm



Length: 21 feet

Width: 1 foot 3 inches

NCHRP Test Level: TL-3, may be used with any speed.

Length of Need: Starting at post # 3, 7 feet 6 inches from front of system (nose piece)

Characteristics:

Re-directive, uni-directional, gating. This system is equipped with a slip base steel post and sand containers, which work in conjunction with one another to dissipate the energy from an impacting vehicle.

Application:

Use to protect concrete barrier and bridge abutments with longitudinal space of less than 125 feet in front of hazard.

Requirements:

Construct concrete pad as per manufacturer's requirements. Use manufacturer's requirements for installing redirecting cable and cable anchor. Redirecting cable anchor will be positioned in such a manner as to allow the redirecting cable to lay

flat on the ground. Slopes of 10:1 or less are required to the front and side approaches, and be free of obstacles. Refer to UDOT STD DWG CC 7 Crash Cushion Type “F” for recovery area requirements and redirecting cable anchor requirements. The manufacturer, supplier or installer of the system will provide the appropriate directional object panel and marker post, UDOT STD DWG CC 1.

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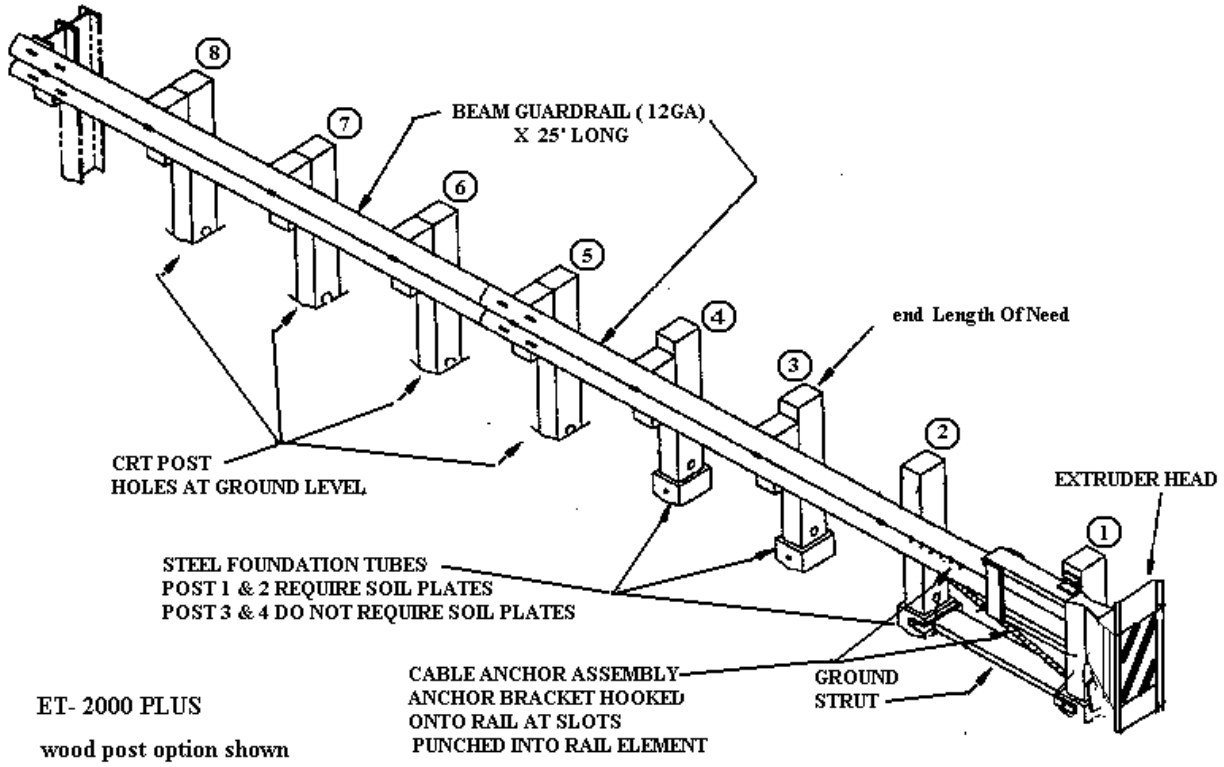
Type G *(Two approved systems. The systems in this type look very similar: see characteristics to distinguish differences.)*

Use to protect the approach end of single face w-beam guardrail. Should be used to protect concrete barrier or bridge parapet with unlimited longitudinal space (125 feet or greater) in front of the hazard when proper transition element is installed. These systems used on tangent or flared barrier installations.

Name: ET-2000™ or ET-PLUS™ from Syro, Inc. A Trinity Industries Co.
www.highwayguardrail.com



Length: 50 feet

Width: 1 foot 8 inches (extruder head)

NCHRP Test Level: TL-3, may be used with any speed.

Length of Need: starting with post #3, 12 feet 6 inches from front of system

Offset: 50:1

Characteristics

Re-directive, unidirectional, gating. Extruder head flattens the rail, which is pushed out the backside of the head. The cable box anchor assembly is hung on

the first rail element using rectangular slots punched into the rail element. The extruder head chute **does not** extend to the cable box assembly attachment point. The extruder head appears to be solid.

Application

Single faced guardrail may be attached to bridge parapet or concrete barrier using a transition element, refer to STD DWG BA 4A. This system can be used with tangent or flared barrier installations.

Requirements

Line Post Options

Wood post:
Posts 1 and 2: 2 foundation tubes, 6 foot long, with shortened break away posts, 45 inches long. Post blocks not required at posts 1 and 2. Ground strut required between posts 1 and 2.

Posts 3 and 4: 2 foundation tubes, 4 foot 6 inches long, without soil plates and shortened break away posts, 45 inches long.

Posts 5 through 8: standard CRT posts

Foundation tubes will be no greater than 4 inches above ground line.

Steel post: Installation will use Hinged Breakaway steel posts (HBA^{TM}), as specified by Manufacturer.

This system uses W6 X 8.5 steel posts.

Posts 1 and 2: lower sections of Hinged Breakaway posts (HBA^{TM}) are 71½ inches in length, upper post are 28 inches in length. The post sections are bolted together. Post blocks are not required at posts 1 and 2. Ground strut required between posts 1 and 2.

Posts 3 through 8: lower sections of Hinged Breakaway posts (HBA^{TM}) are 43½ inches in length, upper sections are 28 inches in length. The post sections are bolted together. Notched wood or composite blocks are required at posts 3 through 8.

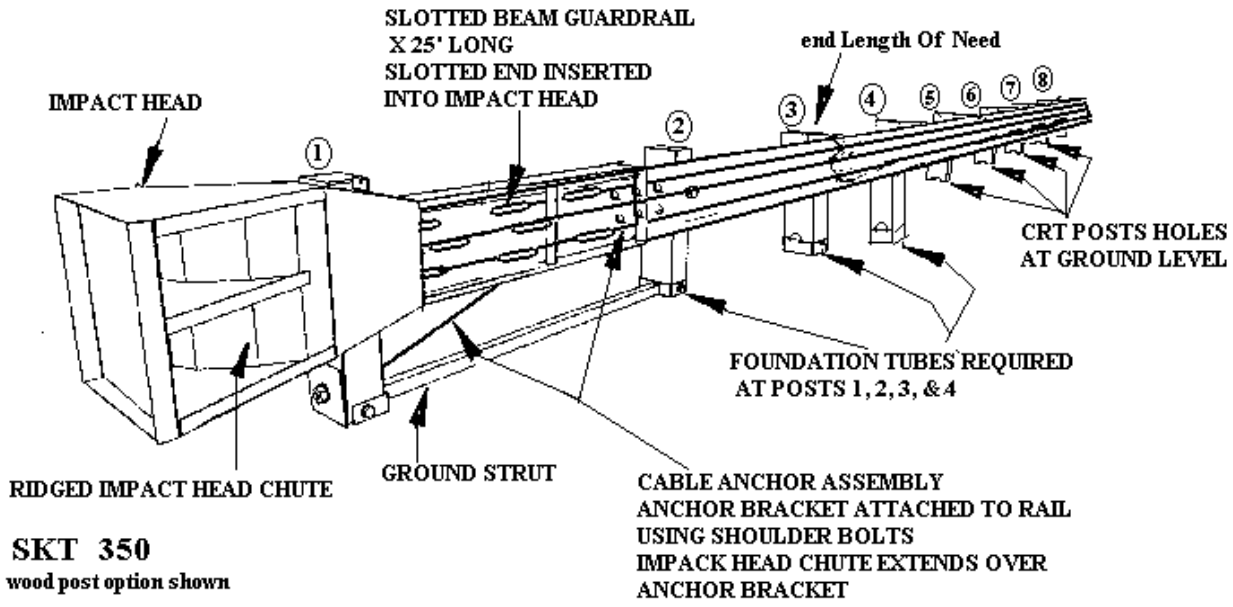
Hinge joint will be placed a maximum of 1 inch above ground line. Hinge section of post will not be placed below ground level.

The Hinged Breakaway Post (HBA^{TM}) used with this system cannot be substituted with any other type of steel breakaway post.

Transition required, as per UDOT STD DRW BA 4A for attachment to concrete barrier or bridge parapet, which will add a length of 25 feet to the installation. System will be installed with a 50:1 offset over the 50 foot length of the system. This will keep the extruder head from encroaching onto the shoulder of the roadway. The 50:1 offset may start at the connection point of the transition element if installed onto concrete barrier or bridge parapet.

Refer to UDOT STD DWG CC 8 Crash Cushion Type G for offset requirements, grading requirements and recovery area requirements. The manufacturer, supplier or installer of the system will provide the appropriate directional object panel and marker post, UDOT STD DWG CC 1.

Name: SKT-350 from Road Systems Inc.,
www.roadsystems.com



Length: 50 feet

Width: 1 foot 8 inches @ impact head

NCHRP Test Level: TL-3 may be used with any speed.

Length of Need: Starting with post #3, 12 feet 6 inches from front of system.

Characteristics

Re-directive, unidirectional, gating. Extruder head kinks the rail element, which is pushed out the backside of the head. The cable box anchor assembly is attached to the first rail element using shoulder bolts and sliding over bolts. The extruder head chute extends to the cable box assembly attachment point. The extruder head is attached to the chute assembly leaving an open space between the face of extruder head and extruder chute.

Application

Single faced guardrail may be attached to bridge parapet or concrete barrier using a transition element, refer to STD DWG BA 4A. This system can be used with tangent or flared barrier installations.

Requirements

Line Posts Options

Wood post:

Posts 1 and 2: 2 foundation tubes, 6 foot long, and shortened break away posts, 45 inches in length. Post blocks are not required at posts 1 and 2. Ground strut required between posts 1 and 2.

Posts: 3 and 4: 2 foundation tubes, 4 foot 6 inches long, without soil plates and shortened break away posts, 45 inches long.

Foundation tubes will be no greater than 4 inches above ground line.

Posts 5, 6, 7, and 8: standard CRT posts, the bottom of the top hole will at ground level, post blocks are required at posts 3 through 8.

Steel posts: installation will use hinged breakaway steel posts, as per manufacturer's design requirements.

This system uses W6 X 9 steel posts.

Post 1: bottom section is 72 inches in length; upper section is 28 3/8-inches in length. The two sections are connected together using a bolt and plates, with a 1/4-inch gap between the two sections.

Post 2: bottom section is 72 inches in length; upper section is 29 7/8-inches in length. The two sections are connected together using a bolts and plates, with a 1/4-inch gap between the two sections. Ground strut required between posts 1 and 2.

Posts 3 through 8: bottom section is 41 1/2- inches in length; upper section is 30 1/4- inches in length. The two sections are connected together using a bolts and plates, with a 1/4-inch gap between the two sections.

Hinge joint will be placed a maximum 1-inch above ground line. Hinge joint of post will not be placed below ground level.

The hinge breakaway post for this system is manufacturer specific and other hinge breakaway post cannot be substituted.

Transition required, as per UDOT STD DWG BA 4A for attachment to concrete barrier or bridge parapet, which will add a length of 25 feet to the installation. System will be installed with a 50:1 offset over the 50-foot length of the system; this will keep the extruder head from encroaching onto the shoulder of the roadway. The 50:1 offset may start at the connection point of the transition element if installed onto concrete barrier or bridge parapet. Refer to UDOT STD DWG CC 8 Crash Cushion Type G for offset requirements, grading requirements and recovery area requirements. The manufacturer, supplier or installer of the system will provide the appropriate directional object panel and marker post, UDOT STD DWG CC 1.

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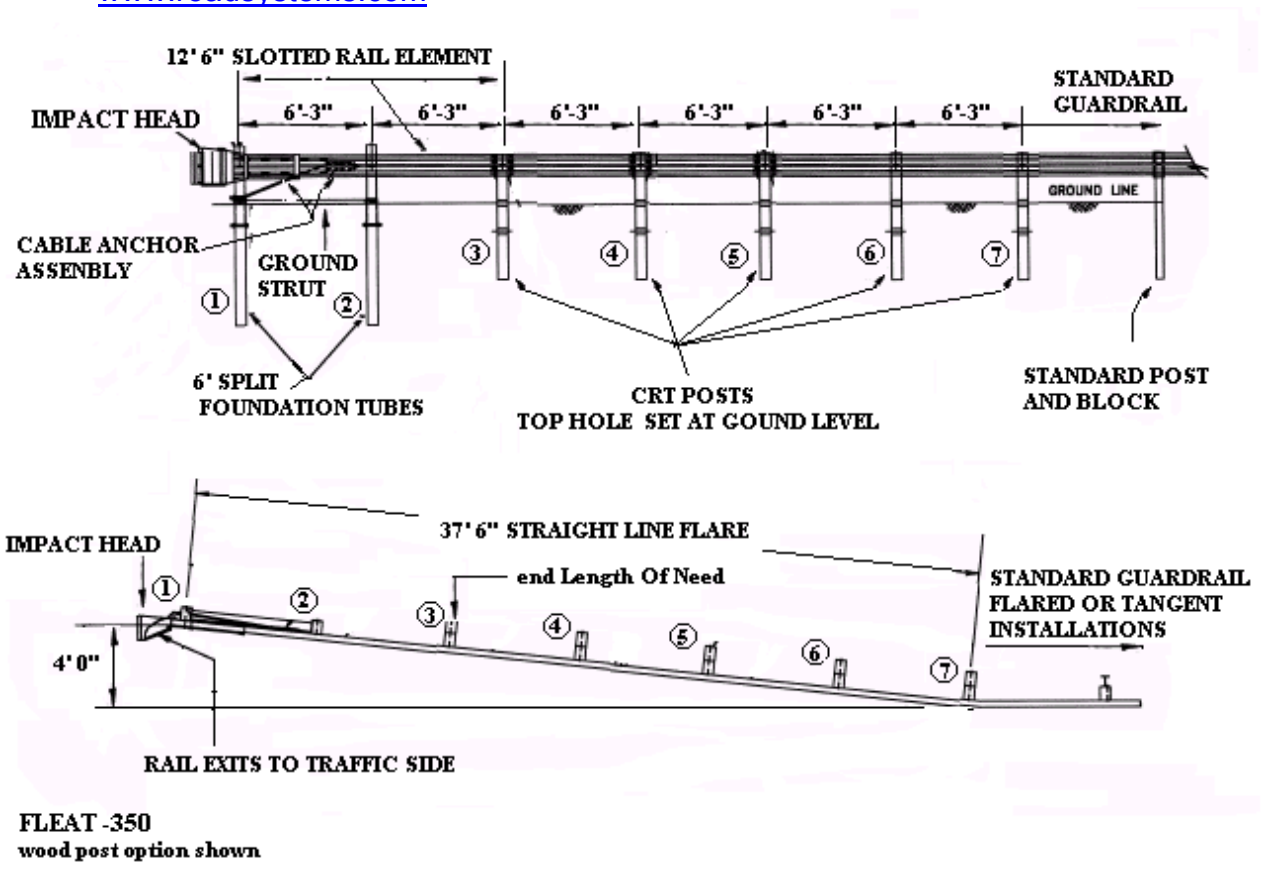
Type H (3 approved systems)

Primarily used when protecting the approach end of single face w-beam guardrail. Should be used to protect concrete barrier or bridge parapet with unlimited longitudinal space 125 feet in front of the hazard when proper transition element is installed. These systems used on tangent or flared barrier installations.

Name: FLEAT-350 from Road Systems, Inc.

www.roadsystems.com



FLEAT -350
wood post option shown

Length: 37 feet 6 inches

Width: 14 inches @ impact head

NCHRP Test Level: TL-3, may be used with any speed.

Offset

4 foot straight line flare over the length of the system. System post offset to be determined upon system layout. When system is used on a flared barrier installation, system will be installed at the same flare rate of the barrier

installation. When this system is used on a tangent guardrail installation the offset will be 4 foot.

Length of Need: Starting with post #3, 12 feet 6 inches from front of system

Application

Tangent or flared, single faced guardrail installations. When be used to protect concrete barrier or bridge parapet, a transition is required as per UDOT STD DWG BA 4A.

Characteristics

Re-directive, unidirectional, gating. The impact head slides over the rail element and when impacted the head kinks the rail element, absorbing the energy from the impacting vehicle, the rail is then pushed out the front side of the head. The cable box anchor assembly is attached to the first rail element using shoulder bolts and sliding over bolts.

Requirements

Line Posts Options

Wood post:

Posts 1 and 2: 72 inch split foundation tubes with 2, 45 inch wood breakaway posts. Posts 1 and 2 do not require a block. Ground strut required between posts 1 and 2.

Posts 3 through 7: standard 72 inch CTR posts, the bottom of the top hole will be place at ground level.

Steel posts:

Post 1 and 2 use 43 inch welded breakaway steel posts set inside 6 foot foundation tubes. Post 1 and 2 do not require a block. Ground strut required between posts 1 and 2.

Post 3 through 7: use 72” long welded steel breakaway post, joint of post will be placed a maximum of 1 inch above ground line. Joint of posts will not be placed below ground level.

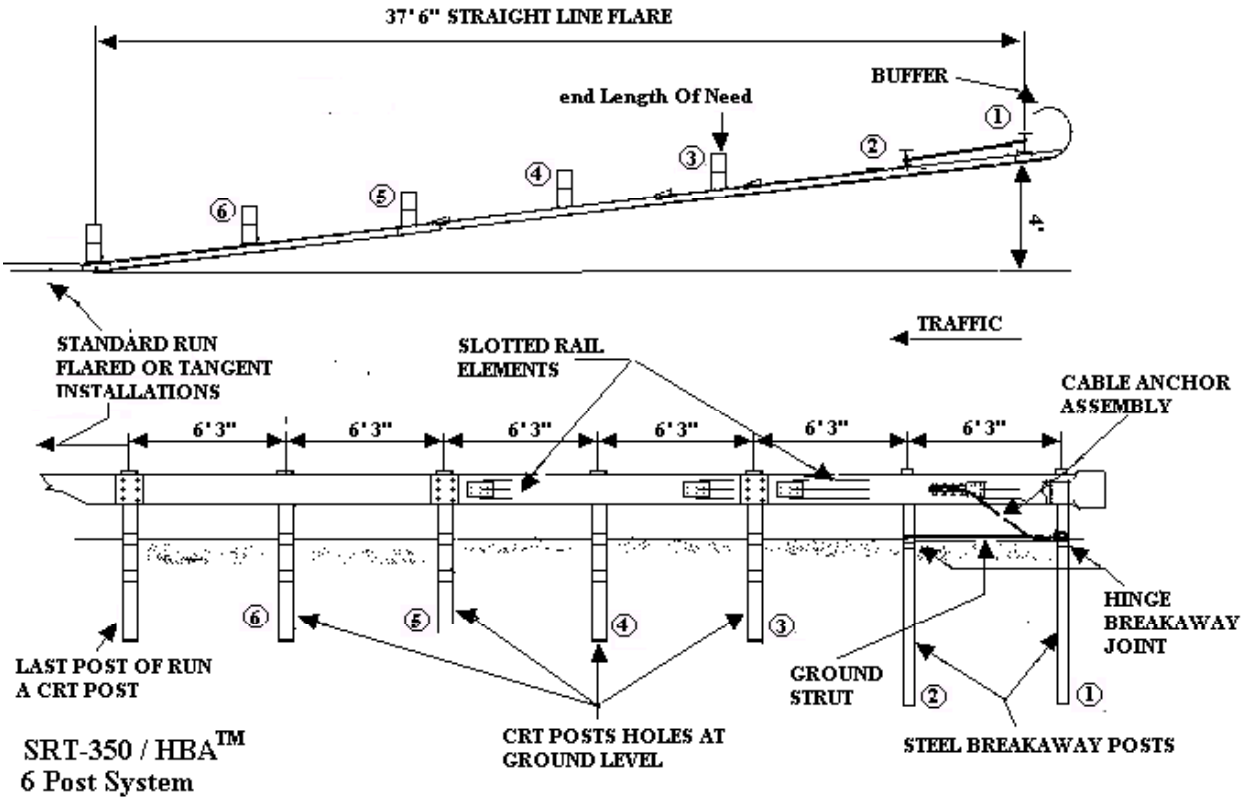
System to use only manufacturer’s specified welded breakaway steel posts.

The foundation tubes will be no greater than 4 inches above ground level.

Transition required, as per UDOT STD DWG BA 4A, for attachment to concrete barrier or bridge parapet. Refer to UDOT STD DWG CC 9A Crash Cushion Type H for offset requirements, grading requirements and recovery area requirements.

The manufacturer, supplier or installer of the system will provide the appropriate directional object panel and marker post, UDOT STD. DWG CC 1.

Name: SRT™/HBA™ 6 Post System, from Syro, Inc., A Trinity Industries Co.
www.highwayguardrail.com



Note: The last line post of the guardrail installation, at the point of the SRT-350/HBA is connected will be a CRT post and is not considered part of the system. When this system is bid and selected the contractor will insure that the CRT post at this location is installed.

Length: 37 feet 6 inches

Width: Width is same as standard guardrail

NCHRP Test Level: TL-3, may be used with any speed.

Offset
4 foot straight line flare over the length of the system.

Length of Need: Starting with post #3, 12 feet 6 inches from front of system.

Characteristics

Re-directive, uni-directional, gating.

Application: Single faced guardrail

Requirements

Posts 1 and 2: use Hinged Breakaway Post (HBA™) as supplied by the manufacturer The posts are constructed in two pieces and bolted together at the hinge point, The lower sections are 71 1/2- inches in length and the uppers section is 43 1/2-inches in length. Post 1 and 2 do not require a block. Ground strut required between posts 1 and 2.

The Hinged Breakaway Post (HBA™) used with this system cannot be substituted with any other type of steel breakaway post.

Post 3 through 6: standard 72 inch CTR posts, the bottom of the top hole will be placed at ground level.

The last post of the guardrail run will use a standard CRT post with a block out and is not considered part of the system.

Transition required, as per UDOT Standard Drawing BA 4A, for attachment to concrete barrier or bridge parapet. An additional 12'6" is required at the end of the transition element in order to meet the requirements of this system with the CRT post as the last post of a guardrail run. Refer to UDOT Standard Drawing CC 9A, End Section Type "H", for grading and recovery area requirements. The manufacturer, supplier or installer of the system will provide the appropriate directional object panel and marker post, UDOT STD. DWG CC 1.

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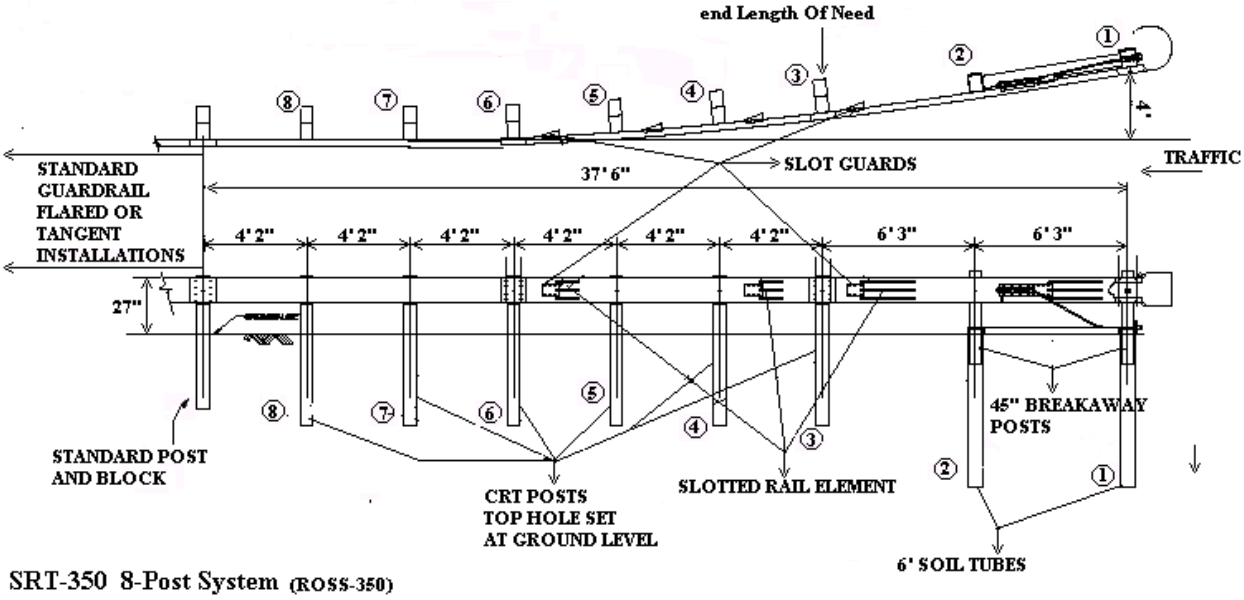
Type H (continued)

Name: SRT-350™ 8 Post System, from Syro, Inc., Trinity Industries
www.highwayguardrail.com



SRT-350 8-Post System (ROSS-350)

Length: 37 feet 6 inches

Width: Width is same as standard guardrail

NCHRP Test Level: TL-3, may be used with any speed.

Length of Need: Starting with post #3, 12 feet 6 inches from front of system.

Offset:
4 foot parabolic flare over the length of the system.

Characteristics:
Re-directive, uni-directional, gating

Application: Single faced guardrail

Requirements:
Posts 1 and 2: 72 inch foundation tubes with 2, 45 inch wood breakaway posts. Posts 1 and 2 do not require a block. Ground strut required between posts 1 and 2.

Posts 3 through 8: standard 72 inch CTR posts, the bottom of the top hole will be placed at ground level.

The foundation tubes will be no greater than 4 inches above ground level.

Transition required, as per UDOT Standard Drawing BA 4A, for attachment to concrete barrier or bridge parapet. Refer to UDOT Standard Drawing CC 9B, End Section Type “H”, SRT-350, for grading and recovery area requirements. The manufacturer, supplier or installer of the system will provide the appropriate directional object panel and marker post, UDOT STD. DWG CC 1.

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Construction Zone Systems

The following are approved construction zone systems, to be supplied by the contractor in most cases.
Not all the systems are NCHRP 350 approved but may be used until such time the service life has expired.

Construction Zone Crash Cushions		
Name	Manufacturer	NCHRP Test Level
ABSORB 350®	Barrier Systems Inc.	TL-2 ≤ 45 MPH, 5 element TL-3 > 45 MPH, 9 elements This is a gating system and a recovery area behind the system of 75' x 20' is required. Recovery area will not have a slope greater than 4:1. When used in freezing conditions an antifreeze solution is required. Fill liquid will be pumped in and out. No fill liquid emptied onto roadway or in the right of ways.
ADIEM 350™	Trinity Industries, Inc.	TL-3 any speed
ADIEM II™	Trinity Industries, Inc.	TL-2, ≤ 45 MPH
NEAT®	Energy Absorption System	TL-2, ≤ 45 MPH This is a gating system and a recovery area behind the system of 75' x 20' is required. Recovery area will not have a slope of greater than 4:1.
QuadGuard CZ™	Energy Absorption System	TL-2 ≤ 45 MPH 3 bay system TL-3 > 45 MPH 6 bay system

Construction Zone Crash Cushions		
Name	Manufacturer	NCHRP Test Level
REACT 350	Roadway Safety Services, Inc.	TL-1, < 45 MPH 4 cylinders TL-2, ≥ 45 MPH ≤ 55 MPH 6 cylinders TL-3, > 55 MPH 9 cylinders
TAU-II™	Barrier Systems Inc.	TL-2, ≤ 45 MPH 4 bay system TL-3 > 45 MPH 8 bay system
SHORTRACC™	Trinity Industries	TL-2, ≤ 45 MPH
TRACC™	Trinity Industries	TL-3 any speed
Sand Barrels "Big Sandy" Energite III® Universal Barrel®	 TrafFix Devices Inc. Energy Absorption Roadway Safety Services	TL-1, TL-2, TL-3 **When using this system all installation requirements as per a permanent application will be met. See Type E permanent crash cushion**
GREAT CZ® This system is not an NCHRP 350 approved system. It may be used until service life has expired.	Energy Absorption System	Speed ≤ 45 MPH, 3 bays Speed > 45 MPH, 6 bays

DOCUMENT SOURCES

NCHRP Report 350 - Recommended Procedures for the Safety Performance Evaluation of Highway Features

NCHRP Report 230 - Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances

NCHRP Synthesis 205- Performance and Operational Experience of Crash Cushions

Design Construction and Maintenance of Highway Safety Features, NHI, 1997

Guide to Standardized Highway Barrier Hardware, Task Force 13 Report, AASHTO

Roadside Design Guide, 2002, AASHTO

Energy Absorption Systems, Inc., Design and Installation Manuals

Energy Absorption Systems, Inc., Safety Needs Analysis Program (SNAP)

Road Systems, Design and Installation Manuals

Trinity Industries Inc., Design and Installation Manuals

Acknowledgments

Mr. John Leonard, UDOT, Central Complex, Salt Lake City, UT

Mr. John C. Durkos, Road Systems, Inc., Stow, OH

Mr. Roger Eagan, Interwest Safety Supply, Denver, CO

Mr. Chuck Norton, Trinity Industries, Inc., Centerville, UT

Mr. Randy Olson, Trinity Industries, Inc., Centerville, UT

Mr. Dick Powers, FHWA, Washington D.C.

Mr. Martin Snow, Universal Steel Corp., Lindon, UT

Mr. Greg Schertz, FHWA, Denver, CO

Mr. Glenn Schulte, UDOT, Central Complex, Salt Lake City, UT

Mr. Bryce Sorenson, Interwest Safety Supply, Provo, UT

Ritchie Taylor
Region 2

MEMORANDUM

UTAH DEPARTMENT OF TRANSPORTATION

DATE: August 18, 1999

TO : Randy Lamoreaux
Director, Project Development

FROM : Sterling C. Davis, P.E. Sterling C. Davis
Engineer for Traffic & Safety

RECEIVED
AUG 13 1999
UDOT TRAFFIC OPERATIONS CENTER

SUBJECT: Water Filled Barrier

There have been a number of locations where water filled barriers have been deployed as protection for work zones. As these devices have not had wide use within UDOT until recently, my staff and I felt that appropriate personnel within the Department needed to be made aware of the proper and approved use of these devices. I would ask that you forward this information on to the appropriate project development personnel.

There is only one water filled barrier approved for use at this time, and it is the Triton Barrier manufactured by Energy Absorption Systems, Inc. We are aware of two other water filled barriers, the Guardian Barrier and the Multi Barrier MB2, that are being marketed and deployed. The Guardian Barrier is not an approved device at this time and the Multi Barrier MB2 has only been approved as a Type I or Type II barricade.

Water filled barriers have some very serious limitations on how and where they should be deployed with consideration being given to length of need, deflection of the barrier and the use as a crash cushion for concrete barrier or other hazards. Due to these limitations, I have requested Glenn Schulte to order application manuals for the Triton Barrier that could be made available for those individuals having a need for this material. Glenn has a manual and will be glad to share it with those who request information or need direction on proper installation of these devices.

Due to some misapplications of this device, I am requesting that those who are considering the use of water filled barriers receive written approval from the Region Traffic Engineer or his representative before using these devices.

If you have any questions or concerns feel free to contact this office.

SCD/cdf

cc: Clint Topham
Dave Miles
Mack Christensen
Fred Lewis
All Region Traffic Engineers

Operational Safety Report

GUIDELINES FOR THE OPERATION SAFETY REPORT (OSR)

11-500.1 OBJECTIVE

To function as the foundation document for the Design Study Report for 4R and Final Surfacing projects.

To function as the support document for a "Request of Design Exception".

To recommend countermeasures to the project Design Engineer from a safety point of view to reduce the number and the severity of accidents and decrease the potential for accidents.

To provide an accident history for Engineering Studies.

11-500.1.1 SCOPE

An OSR may be prepared for any segment of road, any intersection, or any structure on any State Route or Interstate Highway.

11-500.1.2 FUNDING

The costs for computer and preparation time for each OSR will be charged to the appropriate project.

11-500.1.3 PROCEDURE

I. Data Preparation

The Information Processing Section prepares related roadway and accident data per the Traffic Studies Engineer's request and meets the following schedule, workload permitting:

Normal	One (1) week
Rush	Three (3) days
ASAP	One (1) day

The roadway and accident data, including a Dynamic Quicklist or an Intersection Report, and an OSR Summary is provided. Additional documents such as Intersection Accident Diagrams, Road Segment Diagrams, etc., may be provided based on the original requester's need. Unless specified otherwise, the accident history provided is on a three-year basis.

1. Intersection as used herein, is defined as the area 150 feet along each leg from the cross point of the intersecting routes.

II. Data Analysis

1. The Traffic Engineer analyzes the provided accident data and identifies patterns, high-frequency accident locations, and contributing circumstances. The results are used to suggest possible causes of the accident patterns and to be a reference of the countermeasure selection during the site review.

2. Accident Rate Analysis

   a) Actual accident rate calculation:
   Two kinds of accident rates are needed - one for intersection, and another for road segments:

INTERSECTION

1. The accident rate of intersections is defined as the number of accidents per million vehicle:

$$Ri = \frac{2 \times A \times (1{,}000{,}000)}{T \times V} \quad \ldots \quad (1)$$

Where:
- Ri = Intersection accident rate
- T = Time period in days
- V = Total average daily traffic entering and departing the intersection
- A = Number of accidents

SEGMENT

2. The accident rate of a road segment is defined as the number of accidents per million vehicle miles:

$$Rs = \frac{A \times 1{,}000{,}000}{T \times V \times L} \quad \ldots \quad (2)$$

Where:
- Rs = Segment accident rate
- T = Days for which accidents are counted, usually 365 days
- V = Average annual daily traffic on a segment
- A = Number of accidents

Equations (1) and (2) are used in the computer program for calculation, and the results are displayed on the computer printout.

b) Expected accident rate calculation:
The expected accident rate is the average accident rate computed over the most recent five-year period for which accident data ia available. The expected accident rate is published by the functional classification of the roadway and by the average annual daily traffic. The functional classifications are as follows:

RURAL: Area outside the boundaries of urban area.

Principal Arterial - Interstate
Principal Arterial - Other
Minor Arterial
Major Collector
Minor Collector
Local

URBAN: Areas within boundaries set by the responsible state and local officials having a population of 50,000 and over.

SMALL URBAN: Urban area with population between 5,000 and 50,000.

Principal Arterial - Interstate
Principal Arterial - Other Freeways or Express
Other Principal Arterial
Minor Arterial
Collector
Local

INTERSECTION: The location where two or more roadways meet or cross.

Unsignalized

Signalized

c) Actual vs. Expected accident rate comparison:
The Rate Quality-Control Method is a statistical test to determine whether or not the actual accident rate is significantly higher than the expected accident rate for road segments or intersection of similar functional classifications. The statistical tests applied are based on the commonly accepted assumption that the accident occurrences fit the Poisson Distribution. A critical accident rate is calculated using the standard deviation and the level of confidence.

The equation is:

$$Rc = Re + K\sqrt{\frac{Re}{M} + \frac{1}{2M}}$$

Where:
- Rc = The critical accident rate (Accidents per million vehicle miles for sections) (Accidents per million vehicles for intersections)
- K = A probability constant, varies for different levels of confidence. 95% is used in the OSR and K=1.645
- Re = Expected accident rate for sections/ intersections
- M = Million of vehicle miles for sections, or million vehicles for intersections.

If the actual accident rate is higher than the critical accident rate, then the subject segment/intersection accident rate is significantly higher than the expected.

d) Severity Index Calculation:
The actual Severity Index will be calculated by computer using following formulas:

$$\frac{SI = \sum_{i=1}^{N} (Si)}{N}$$

Where:
- SI = Severity Index
- N = Total Number of Injured Persons
- Si = Severity of Injured Person # i

The injury severity is categorized into five (5) levels, i.e from 1 to 5 representing:

1. Property damage only (PDO)
2. Possible injury
3. Nonincapacitating evident injury
4. Incapacitating
5. Fatal accident respectively

The expected Severity Index is derived from Statewide accident data, and is published by functional classification of road segments or intersections.

III. Surveillance Team On-Site Review

All requested segments/intersections should receive an on-site review by a surveillance team, typically composed of the following members:

1. Traffic and Safety Design Representative
2. Traffic and Safety Studies Engineer or his representative.
3. District Representative
4. FHWA Representative

The Surveillance Team, using the accident analysis results as a guide for diagnosing existing accident locations and patterns, prepares a list of possible countermeasures by milepoint. Countermeasures for only accident related non-maintenance road deficiencies are recommended for consideration during the design of project.

IV. Report preparation

1. The accident reduction factor is used in the calculation of expected benefit:

$$PVAC = [R(3{,}000 \times NSI + 8{,}500 \times NS2 + 19{,}000 \times NS3 + 47{,}000 \times NS4 + 1{,}700{,}000 \times NS5)] \times PWF$$

Where: PVAC = present value of projected accident cost decrease due to countermeasures;

R = Total Reduction Factor
$= 1 - (1-R_1)(1-R_2) \ldots (1-Rn)$

NS1 = Number of severity "1" accidents

NS2 = Number of severity "2" accidents

NS3 = Number of severity "3" accidents

NS4 = Number of severity "4" accidents

NS5 = Number of severity "5" accidents

R_1 = Reduction factor of first probable countermeasure

R_2 = Reduction factor of second probable countermeasure

R_n = Reduction factor of nth probable countermeasure

Sources of reduction factor are available research results. PWF is the present value factor for eight percent (8%) return and estimated life of the countermeasure. (i.e. PWF for 20 years at 8% = 9.818)

2. The OSR should contain following items:

a) Route Number and Project Number
b) Beginning and ending milepost
c) Number of accidents by year for the past three (3) years
d) Actual and expected accident rate
e) Actual and expected severity index
f) Brief description of analysis results
g) Recommended countermeasures by milepoint
h) Anticipated annual benefit (if possible)

Source documents, including the computer printout, location map sheet, milepost logs, etc., will be kept in the Traffic and Safety Division and will be available for the requester's for further analysis.

OSR Process

The Division of Traffic and Safety has been reviewing the products we supply to our customers. One of these products, the Operational Safety Report (OSR), provides information on the safety related aspects of a proposed project. The report entails a review of the accident history, existing features, and a recommendation to correct these issues. Typically, the OSR is delivered just prior to the DSR sign off, and has not played a major role in the development of the scope of the proposed project.

The feed back from our customers who use the report indicate they would like the information in the OSR to be provided much earlier in the process. In conjunction with Program Development, the Division is working to incorporate the OSR concept in both the concept and the scoping phase of the project. The information will then be available to the Project Manager as they develop the final concept and the scope for the project.

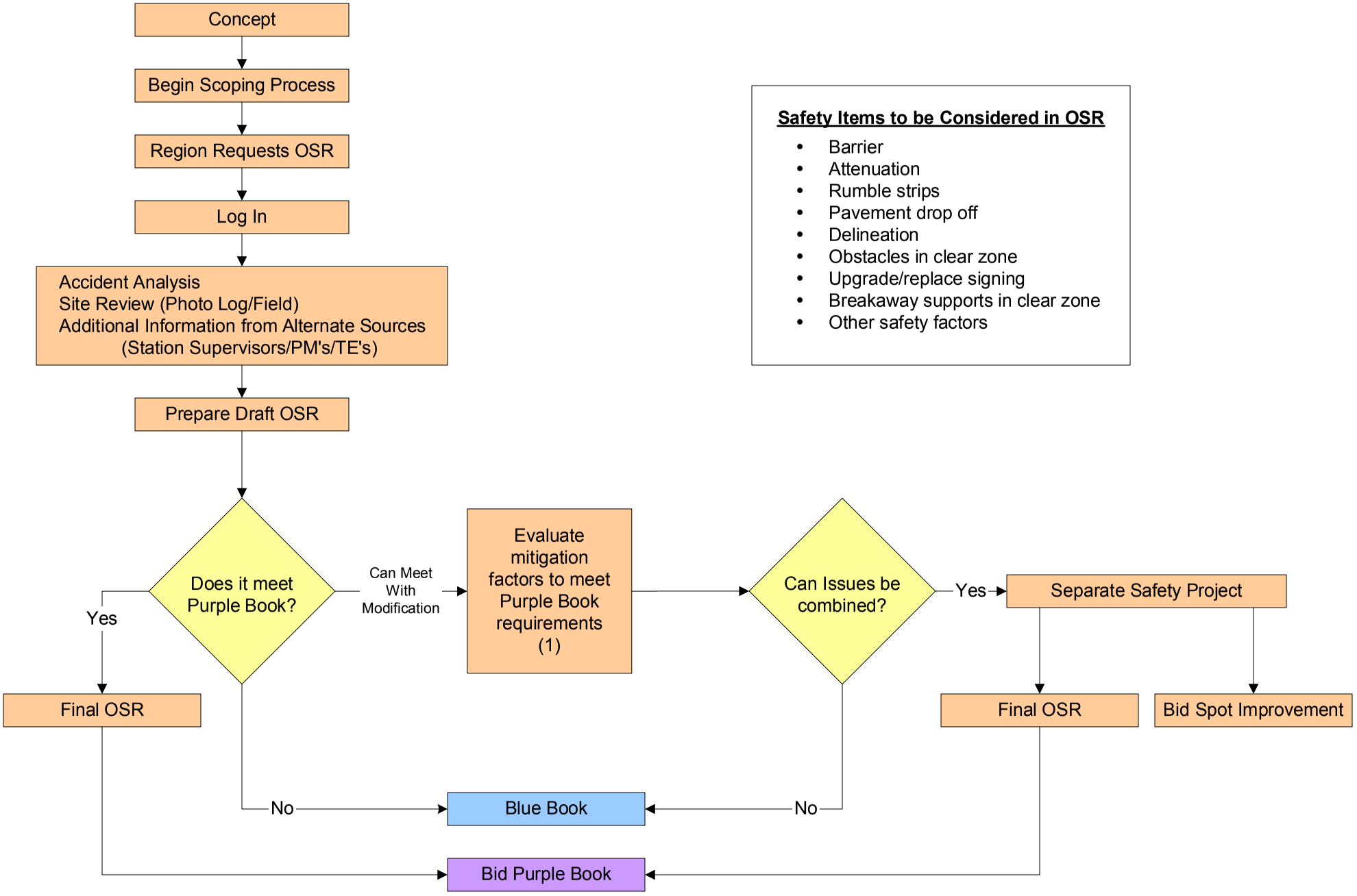
This fits well with the proposed process flow chart for the use of OSR's in Purple Book projects. The OSR will become one of the tools available to the Project Manager to identify both safety issues and potential corrective action. In the Purple Book Process, we propose to follow the following steps:

1. Immediately after the initial concept for the project is developed, the Project Manager in the Region will request an OSR form the Traffic and Safety Operations Engineer.

2. The request will be logged in, and several processes will begin. The accident history of the section will be reviewed and evaluated, looking for any potential areas of concern, frequency, similarity, or other things which might indicate a problem area. A site review will be conducted, either in the form of a photo log review for simple projects with no accident concerns, or a site visit to obtain more detailed information. The information collection may include discussions with individuals knowledgeable of the area, including the Project Manager, Maintenance personnel, Region Traffic Engineers, Loss Control Managers, etc.

3. A draft OSR with safety recommendations will be prepared, and a determination will be made if the project meets the requirements of a Purple Book. This review has three possible outcomes: the project meets the requirements, and the final OSR is prepared and sent to the Project Manager, the recommendations are included in the project scope, and the project is bid. The second option is the project does not come close to meeting the requirements of a Purple Book, and it must be re-evaluated, and bid as a Blue Book project with the safety recommendations included. The third option is the project initially may not meet the requirements of a Purple Book, but may do so with some help. We would review the safety recommendations in the OSR, and determine if the ones which restrict the project from meeting the Purple Book status may be eliminated by the addition of a companion project, possibly funded through Safety funds. This could include grouping several similar recommendations from multiple projects together to provide an enhancement to the highway system. If this approach proved feasible, then these elements would be taken out of the proposed project, a final OSR would be issued, and the Purple Book Project would be bid. A different project would be generated to correct the issues and would also be bid. If the use of an additional small project could not correct the deficiencies, then the project must be re-evaluated, and bid as a Blue Book project with the safety recommendations included.

OSR Process for Purple Book



(1) Factors include: combining issues with other projects, modify project scope, address issues

Hazard Elimination

POLICY AND PROCEDURES FOR
THE ROADWAY SAFETY IMPROVEMENT (RSI) PROGRAM

PURPOSE

The purpose of this policy and procedures statement is to fulfill the requirements outlined in 23 CFR 924, Subchapter J, "Highway Safety Improvement Program." The overall objective on all Utah roads is to:

1. Reduce the number of accidents;
2. Reduce the severity of accidents;
3. Decrease the potential for accidents; and,
4. Make the most efficient use of available safety funds.

These objectives will be accomplished through identifying high accident locations and developing a program of roadway safety improvement projects to address those locations. Identified locations may be on any public roadway. Funding for the Roadway Safety Improvement (RSI) Program is apportioned under 23 U.S.C. 133(d)(1).

UDOT's RSI Program is an update to the previous UDOT HES Program.

RSI PROJECT COORDINATOR

The UDOT Engineer for Traffic and Safety, or designee, (The Engineer) shall be responsible for the implementation and coordination of the Roadway Safety Improvement Program. The Engineer and representatives from Utah Highway Patrol, Utah Highway Safety Office, local law enforcement, local government officials, UDOT Region Directors, UDOT Region Traffic Engineers, and the UDOT Traffic and Safety Division shall be included, as appropriate, as members of the RSI Team in each Region. The Engineer shall be the RSI Team coordinator, and is responsible for program development, project identification and review, development of the accident locations list, programming the funding, transferring proposed projects to design and construction phases in accordance with UDOT established procedures, and evaluation of the constructed RSI projects.

RSI PROGRAM PROCESS

1. Collection of Crash, Traffic, and Roadway Data

UDOT currently maintains a database that contains every reported accident that occurs within the state of Utah. The Central Accident Records System (CARS) database also contains roadway and traffic data for all state routes and federal-aid routes. Roadway and traffic data for the database (the Roads File) is supplied and maintained by the UDOT Planning Division.

2. Identification of Safety Spot Locations (SSLs)

The initial effort for identifying roadway safety improvement locations is to accumulate a list of SSLs throughout the State where the numbers of accidents and/or the severity of accidents are higher than expected, or where contributing circumstances are unknown. The process to assemble the SSLs is a two-step process:

a. A statistical analysis of the CARS database is conducted to identify candidate accident locations. The statistical analysis is also conducted in a two-step process for roadway segments, and for roadway intersections.
   1. For roadway segments, a slider function (automated within the CARS database) is used to screen all roadway segments for those segments that reach threshold numbers of accidents within a 0.5-mile segment and 0.1-mile intervals.
   2. For intersections, the process is much more labor intensive. A screening for crashes within the CARS database at intersections is possible, but is very limited because of the format of the current Roads File. Essentially, all crashes that have been assigned an "intersection type" during the coding process will be queried, and the locations that reach a threshold number of crashes will be identified. Unfortunately, because of the Roads File, the database is unable to create an automated screened intersection report that includes all intersecting roadways at a given intersection. The crashes occurring on the intersecting roadway(s) will be summed manually to arrive at the final prioritized listing.

b. Additional locations will be considered for addition to the SSLs as identified by UDOT Region engineers, other state agencies, the FHWA, the Utah Highway Patrol, local law enforcement, local government officials, and the general public.

   The State of Utah contains 29 counties and approximately 231 cities. While it may not be feasible to personally contact 260 separate jurisdictions, the following strategies will be used to maximize participation of local jurisdictions:
   1. Cities and counties with current US Census populations greater than 15,000 will be contacted annually via telephone and/or letter to solicit high accident locations and to provide education on the RSI program. According to the 2000 US Census, the 15,000 threshold will result in 30 cities and 15 counties being contacted annually.
   2. Efforts to reach the rest of the cities and counties will focus primarily on partnering efforts with the Utah League of Cities and Towns. Annual participation in the Utah League of Cities and Towns' Road School is one particularly effective way to reach multiple jurisdictions. The process of reaching and involving local jurisdictions will be continually refined.

c. The deadline for submission of locations to the Engineer for inclusion in the SSL lists is October 1st annually in order to be considered for programming in the current year's STIP process.

3. Selection of Locations for Preliminary Analysis

Candidate locations on the SSLs are prioritized and selected for preliminary analysis using weighted accident rates, GIS plot maps, and collision diagrams. This selection process follows the following steps:

a. Three year accident GIS plot maps and/or computer generated lists by county summarizing accidents on all roads and streets are prepared.

b. Accidents for each location are equated to property damage accidents using a severity rating to determine weighted accidents. The following factors are used:

1. One fatal accident equals twenty property damage accidents.
2. One injury accident equals five property damage accidents.
3. The average annual daily traffic is used to determine weighted accident rates.

These factors are used to rank and prioritize the candidate locations on the SSLs for further analysis.

c. Detailed accident summary reports are obtained for each location for the most recent three-year period using the CARS database. The nature of the crashes is analyzed to determine if there are any apparent crash patterns.

d. Each location is compared to UDOT's 5-yr STIP to ensure coordination between the two programs. Potential RSI projects within the boundaries of a project on the STIP will be advanced in this process, but funding will be determined on a case-by-case basis. Whether or not the potential RSI project is funded, the safety information developed will be provided to the Region for use in the development of the STIP project.

e. Collision diagrams are prepared for each selected location.

f. Potentially hazardous locations may be selected and ranked based on a comparison to locations that displayed characteristics similar to those at improved locations before safety improvements, and resulted in documented accident reduction after the improvements.

g. An investigation file is prepared for each selected location, which includes data noted in a. through e. above.

4. Field Inspection of Individual Locations

An on-site inspection or a review by video-log is made of each selected location by the RSI team. The reviews focus on the highest-ranked locations first. The timeframe to complete a review on every location in each SSL will be dependent on the availability of the RSI team members.

a. A preliminary determination of the cause of the accidents at each location is made and possible mitigation measures are identified, both pending further investigation.

b. Observations are made regarding sight distance, approach speeds, conditions of roadway surface, geometrics, lighting, existing traffic control devices, driver behavior, and other pertinent features.

c. People living or doing business in the immediate area are occasionally contacted regarding their observations of what might be contributing to the accidents.

d. A Location Reviews Report is by the Engineer to summarize the problem, mitigation discussed, and preliminary recommendations for all sites inspected. The report is sent to the inspection team members, FHWA, and Region Directors.

e. The Location Reviews Report may recommend that a location is not appropriate for the RSI program, but the report may identify other methods for dealing with a problem at a given location.

5. Selected Locations Analyzed, Corrective Action Proposed, and Listing Prepared

Using the investigative file and Location Review Report, each location identified is analyzed, corrective action proposed and a final priority listing prepared by the Engineer.

a. A list is developed which includes the location, the proposed improvement, a cost estimate for the improvement, and the benefit/cost ratio for each location.

1. The Equivalent Uniform Annual Cost (EUAC) of the proposed improvement is calculated by the Engineer using an interest rate and a design life based on the current economy and the improvement selected. UDOT's "Quantities and Average Low Bid Unit Prices" listing will be the basic source for estimating the cost of each improvement.

2. The Equivalent Uniform Annual Benefit (EUAB) of the proposed improvement is calculated by the Engineer using the Bailey Method Attachment to FHWA Technical Advisory T7570.1 (modified), and current accident costs as determined by FHWA Technical Advisory T7570.2 dated October 31, 1994, and subsequent updates. Accident Reduction Factors (ARF) used to calculate the reduction in accidents associated with a given improvement are taken from the following sources:

a). FHWA
b). Kentucky Transportation Center, "Development of Accident Reduction Factors" (Research Report KTC-96-13, June 1996)

The Kentucky ARF Study used a comprehensive survey of 44 states and a literature review of 61 documents to determine the best estimates of reduction factors for given safety improvements.

As more data becomes available, UDOT will eventually develop a localized database for Utah using actual reduction factors resulting from constructed RSI projects. Until that time, the Kentucky ARF study is the best information available.

3. The Engineer determines the benefit/cost ratio for each location by dividing the calculated Equivalent Uniform Annual Benefit (EUAB) resulting from the improvement by the calculated Equivalent Uniform Annual Cost (EUAC) of making the improvement. The locations with benefit/cost ratios of less than one are not included in the list of recommended Roadway Safety Improvement projects.

b. The Engineer reviews the proposed projects, reviews the intended improvement(s), and prioritizes the proposed projects based on the following factors.

1. Costs

2. Benefits

3. B/C Ratio

4. Plan Development Schedule
   a). Survey
   b). Utilities
   c). R.O.W.
   d). Design Schedule

5. Coordination with other programmed UDOT projects.

6. Allocation of a portion of apportioned funds to areas of the State as defined by current UDOT Region boundaries and the type and number of accidents occurring in each.

c. The proposed RSI program, with cost estimate and benefit/cost ratio, is presented for review at the annual Region Statewide Transportation Improvement Program (STIP) workshops (usually held in January).

d. Following the Region STIP workshops, the recommended program of RSI projects is submitted to the Transportation Commission for review and approval as part of the STIP.

6. Implementation

The scheduling and implementation of RSI Projects shall be in accordance with procedures set forth in 23 CFR (ie. Parts 630 and 635) and the following:

a. For each RSI project in the STIP, UDOT Region Directors shall be responsible for assigning a project manager, for obligating federal

funding, for developing the design, and for advising the Engineer of the progress and status of each project.

b. The UDOT Region Project Manager shall be responsible for the timely completion of the projects they are assigned. When applicable, this shall include, but not be limited to design plans and specifications, environmental studies, funding agreements, maintenance & non-encroachment agreements, coordination of right-of-way acquisition, utility agreements, and delivery of final plans to UDOT Construction Division, Contracts, Estimates and Agreements Section for advertisement.

c. The Project Manager shall involve the FHWA, the Engineer, and other representatives of the Traffic and Safety Division in the development of each project in an advisory role.

7. Evaluation

Three years after construction of the improvement is completed, the Engineer will evaluate each Roadway Safety Improvement project based on a comparison of accidents three years prior to the improvement to three years following the improvement. The comparison will be made for accident numbers, accident rates, and accident severity. The evaluation process is similar to the process for determining the estimated benefit-cost ratio described in Section 5, except actual costs and actual savings are used.

Miscellaneous

ALPHABETICAL LIST OF UNITS

Factors with an asterisk (*) are exact

(Symbols of SI units given in parentheses)

To convert from	to	Multiply by
abampere	ampere (A)	1.000 000*E+01
abcoulomb	coulomb (C)	1.000 000*E+01
abfarad	farad (F)	1.000 000*E+09
abhenry	henry (H)	1.000 000*E−09
abmho	siemens (S)	1.000 000*E+09
abohm	ohm (Ω)	1.000 000*E−09
abvolt	volt (V)	1.000 000*E−08
acre foot[13]	cubic metre (m^3)	1.233 489 E+03
acre[13]	square metre (m^2)	4.046 873 E+03
ampere hour	coulomb (C)	3.600 000*E+03
angstrom	metre (m)	1.000 000*E−10
are	square metre (m^2)	1.000 000*E+02
astronomical unit	metre (m)	1.495 979 E+11
atmosphere, standard	pascal (Pa)	1.013 250*E+05
atmosphere, technical (= 1 kgf/cm^2)	pascal (Pa)	9.806 650*E+04
bar	pascal (Pa)	1.000 000*E+05
barn	square metre (m^2)	1.000 000*E−28
barrel (for petroleum, 42 gal)	cubic metre (m^3)	1.589 873 E−01
board foot	cubic metre (m^3)	2.359 737 E−03
British thermal unit (International Table)[14]	joule (J)	1.055 056 E+03
British thermal unit (mean)	joule (J)	1.055 87 E+03
British thermal unit (thermochemical)	joule (J)	1.054 350 E+03
British thermal unit (39°F)	joule (J)	1.059 67 E+03
British thermal unit (59°F)	joule (J)	1.054 80 E+03
British thermal unit (60°F)	joule (J)	1.054 68 E+03
Btu (International Table)·ft/(h·ft^2·°F) (thermal conductivity)	watt per metre kelvin [W/(m·K)]	1.730 735 E+00
Btu (thermochemical)·ft/(h·ft^2·°F) (thermal conductivity)	watt per metre kelvin [W/(m·K)]	1.729 577 E+00
Btu (International Table)·in/(h·ft^2·°F) (thermal conductivity)	watt per metre kelvin [W/(m·K)]	1.442 279 E−01
Btu (thermochemical)·in/(h·ft^2·°F) (thermal conductivity)	watt per metre kelvin [W/(m·K)]	1.441 314 E−01
Btu (International Table)·in/s·ft^2·°F) (thermal conductivity)	watt per metre kelvin [W/(m·K)]	5.192 204 E+02
Btu (thermochemical)·in/(s·ft^2·°F) (thermal conductivity)	watt per metre kelvin [W/(m·K)]	5.188 732 E+02
Btu (International Table)/h	watt (W)	2.930 711 E−01
Btu (International Table)/s	watt (W)	1.055 056 E+03
Btu (thermochemical)/h	watt (W)	2.928 751 E−01
Btu (thermochemical)/min	watt (W)	1.757 250 E+01
Btu (thermochemical)/s	watt (W)	1.054 350 E+03
Btu (International Table)/ft^2	joule per square metre (J/m^2)	1.135 653 E+04
Btu (thermochemical)/ft^2	joule per square metre (J/m^2)	1.134 893 E+04

[13] The U.S. Metric Law of 1866 gave the relationship, 1 metre equals 39.37 inches. Since 1893 the U.S. yard has been derived from the metre. In 1959 a refinement was made in the definition of the yard to bring the U.S. yard and the yard used in other countries into agreement. The U.S. yard was changed from 3600/3937 m to 0.9144 m exactly. The new length is shorter by exactly two parts in a million.

At the same time it was decided that any data in feet derived from and published as a result of geodetic surveys within the U.S. would remain with the old standard (1 ft = 1200/3937 m) until further decision. This foot is named the U.S. survey foot.

All conversion factors for units of land measure in these tables referenced to this footnote are based on the U.S. survey foot and the following relationships: 1 fathom = 6 feet; 1 rod (pole or perch) = 16½ feet; 1 chain = 66 feet; 1 mile (U.S. statute) = 5280 feet.

[14] The Fifth International Conference on the Properties of Steam in 1956 defined the calorie (International Table) as 4.1868 J. Therefore, the exact conversion for Btu (International Table) is 1.055 055 852 62 E+03 J.

To convert from	to	Multiply by
Btu (International Table)/(ft²·s)	watt per square metre (W/m²)	1.135 653 E+04
Btu (International Table)/(ft²·h)	watt per square metre (W/m²)	3.154 591 E+00
Btu (thermochemical)/(ft²·h)	watt per square metre (W/m²)	3.152 481 E+00
Btu (thermochemical)/(ft²·min)	watt per square metre (W/m²)	1.891 489 E+02
Btu (thermochemical)/(ft²·s)	watt per square metre (W/m²)	1.134 893 E+04
Btu (thermochemical)/(in²·s)	watt per square metre (W/m²)	1.634 246 E+06
Btu (International Table)/(h·ft²·°F) (thermal conductance)[15]	watt per square metre kelvin [W/(m²·K)]	5.678 263 E+00
Btu (thermochemical)/(h·ft²·°F) (thermal conductance)[15]	watt per square metre kelvin [W/(m²·K)]	5.674 466 E+00
Btu (International Table)/(s·ft²·°F)	watt per square metre kelvin [W/(m²·K)]	2.044 175 E+04
Btu (thermochemical)/(s·ft²·°F)	watt per square metre kelvin [W/(m²·K)]	2.042 808 E+04
Btu (International Table)/lb	joule per kilogram (J/kg)	2.326 000*E+03
Btu (thermochemical)/lb	joule per kilogram (J/kg)	2.324 444 E+03
Btu (International Table)/(lb·°F) (heat capacity)	joule per kilogram kelvin [J/(kg·K)]	4.186 800*E+03
Btu (thermochemical)/(lb·°F) (heat capacity)	joule per kilogram kelvin [J/(kg·K)]	4.184 000*E+03
Btu (International Table)/ft³	joule per cubic metre (J/m³)	3.725 895 E+04
Btu (thermochemical)/ft³	joule per cubic metre (J/m³)	3.723 402 E+04
bushel (U.S.)	cubic metre (m³)	3.523 907 E−02
calorie (International Table)[14]	joule (J)	4.186 800*E+00
calorie (mean)	joule (J)	4.190 02 E+00
calorie (thermochemical)	joule (J)	4.184 000*E+00
calorie (15°C)	joule (J)	4.185 80 E+00
calorie (20°C)	joule (J)	4.181 90 E+00
calorie (kilogram, International Table)	joule (J)	4.186 800*E+03
calorie (kilogram, mean)	joule (J)	4.190 02 E+03
calorie (kilogram, thermochemical)	joule (J)	4.184 000*E+03
cal (thermochemical)/cm²	joule per square metre (J/m²)	4.184 000*E+04
cal (International Table)/g	joule per kilogram (J/kg)	4.186 800*E+03
cal (thermochemical)/g	joule per kilogram (J/kg)	4.184 000*E+03
cal (International Table)/(g·°C)	joule per kilogram kelvin [J/(kg·K)]	4.186 800*E+03
cal (thermochemical)/(g·°C)	joule per kilogram kelvin [J/(kg·K)]	4.184 000*E+03
cal (thermochemical)/min	watt (W)	6.973 333 E−02
cal (thermochemical)/s	watt (W)	4.184 000*E+00
cal (thermochemical)/(cm²·s)	watt per square metre (W/m²)	4.184 000*E+04
cal (thermochemical)/(cm²·min)	watt per square metre (W/m²)	6.973 333 E+02
cal (thermochemical)/(cm²·s)	watt per square metre (W/m²)	4.184 000*E+04
cal (thermochemical)/(cm·s·°C)	watt per metre kelvin [W/(m·K)]	4.184 000*E+02
cd/in²	candela per square metre (cd/m²)	1.550 003 E+03
carat (metric)	kilogram (kg)	2.000 000*E−04
centimetre of mercury (0°C)	pascal (Pa)	1.333 22 E+03
centimetre of water (4°C)	pascal (Pa)	9.806 38 E+01
centipoise (dynamic viscosity)	pascal second (Pa·s)	1.000 000*E−03
centistokes (kinematic viscosity)	square metre per second (m²/s)	1.000 000*E−06
chain[13]	metre (m)	2.011 684 E+01
circular mil	square metre (m²)	5.067 075 E−10
clo	kelvin square metre per watt (K·m²/W)	1.55 E−01
cup	cubic metre (m³)	2.365 882 E−04
curie	becquerel (Bq)	3.700 000*E+10
darcy[16]	square metre (m²)	9.869 233 E−13
day	second (s)	8.640 000*E+04
day (sidereal)	second (s)	8.616 409 E+04
degree (angle)	radian (rad)	1.745 329 E−02
degree Celsius	kelvin (K)	$T_K = t_C + 273.15$
degree centigrade	[see 3.4.2]	
degree Fahrenheit	degree Celsius (°C)	$t_C = (t_F - 32)/1.8$

[15] In ISO 31 this quantity is called *coefficient of heat transfer*.

[16] The darcy is a unit for measuring permeability of porous solids.

To convert from	to	Multiply by
degree Fahrenheit	kelvin (K)	$T_K = (t_F + 459.67)/1.8$
degree Rankine	kelvin (K)	$T_K = T_R/1.8$
°F·h·ft²/Btu (International Table) (thermal resistance)[17]	kelvin square metre per watt (K·m²/W)	1.761 102 E−01
°F·h·ft²/Btu (thermochemical) (thermal resistance)[17]	kelvin square metre per watt (K·m²/W)	1.762 280 E−01
°F·h·ft²/[Btu (International Table)·in] (thermal resistivity)	kelvin metre per watt (K·m/W)	6.933 471 E+00
°F·h·ft²/[Btu (thermochemical)·in] (thermal resistivity)	kelvin metre per watt (K·m/W)	6.938 113 E+00
denier	kilogram per metre (kg/m)	1.111 111 E−07
dyne	newton (N)	1.000 000*E−05
dyne·cm	newton metre (N·m)	1.000 000*E−07
dyne/cm²	pascal (Pa)	1.000 000*E−01
electronvolt	joule (J)	1.602 19 E−19
EMU of capacitance	farad (F)	1.000 000*E+09
EMU of current	ampere (A)	1.000 000*E+01
EMU of electric potential	volt (V)	1.000 000*E−08
EMU of inductance	henry (H)	1.000 000*E−09
EMU of resistance	ohm (Ω)	1.000 000*E−09
ESU of capacitance	farad (F)	1.112 650 E−12
ESU of current	ampere (A)	3.335 6 E−10
ESU of electric potential	volt (V)	2.997 9 E+02
ESU of inductance	henry (H)	8.987 554 E+11
ESU of resistance	ohm (Ω)	8.987 554 E+11
erg	joule (J)	1.000 000*E−07
erg/(cm²·s)	watt per square metre (W/m²)	1.000 000*E−03
erg/s	watt (W)	1.000 000*E−07
faraday (based on carbon-12)	coulomb (C)	9.648 70 E+04
faraday (chemical)	coulomb (C)	9.649 57 E+04
faraday (physical)	coulomb (C)	9.652 19 E+04
fathom[13]	metre (m)	1.828 804 E+00
fermi (femtometre)	metre (m)	1.000 000*E−15
fluid ounce (U.S.)	cubic metre (m³)	2.957 353 E−05
foot	metre (m)	3.048 000*E−01
foot (U.S. survey)[13]	metre (m)	3.048 006 E−01
foot of water (39.2°F)	pascal (Pa)	2.988 98 E+03
ft²	square metre (m²)	9.290 304*E−02
ft²/h (thermal diffusivity)	square metre per second (m²/s)	2.580 640*E−05
ft²/s	square metre per second (m²/s)	9.290 304*E−02
ft³ (volume; section modulus)	cubic metre (m³)	2.831 685 E−02
ft³/min	cubic metre per second (m³/s)	4.719 474 E−04
ft³/s	cubic metre per second (m³/s)	2.831 685 E−02
ft⁴ (second moment of area)[18]	metre to the fourth power (m⁴)	8.630 975 E−03
ft/h	metre per second (m/s)	8.466 667 E−05
ft/min	metre per second (m/s)	5.080 000*E−03
ft/s	metre per second (m/s)	3.048 000*E−01
ft/s²	metre per second squared (m/s²)	3.048 000*E−01
footcandle	lux (lx)	1.076 391 E+01
footlambert	candela per square metre (cd/m²)	3.426 259 E+00
ft·lbf	joule (J)	1.355 818 E+00
ft·lbf/h	watt (W)	3.766 161 E−04
ft·lbf/min	watt (W)	2.259 697 E−02
ft·lbf/s	watt (W)	1.355 818 E+00
ft-poundal	joule (J)	4.214 011 E−02
g, standard free fall	metre per second squared (m/s²)	9.806 650*E+00

[17] In ISO 31 this quantity is called *thermal insulance* and the quantity *thermal resistance* has the unit K/W.

[18] This is sometimes called the moment of section or area moment of inertia of a plane section about a specified axis.

To convert from	to	Multiply by
gal	metre per second squared (m/s^2)	1.000 000*E−02
gallon (Canadian liquid)	cubic metre (m^3)	4.546 090 E−03
·lon (U.K. liquid)	cubic metre (m^3)	4.546 092 E−03
on (U.S. dry)	cubic metre (m^3)	4.404 884 E−03
on (U.S. liquid)	cubic metre (m^3)	3.785 412 E−03
allon (U.S. liquid) per day	cubic metre per second (m^3/s)	4.381 264 E−08
gallon (U.S. liquid) per minute	cubic metre per second (m^3/s)	6.309 020 E−05
gallon (U.S. liquid) per hp·h (SFC, specific fuel consumption)	cubic metre per joule (m^3/J)	1.410 089 E−09
gamma	tesla (T)	1.000 000*E−09
gauss	tesla (T)	1.000 000*E−04
gilbert	ampere (A)	7.957 747 E−01
gill (U.K.)	cubic metre (m^3)	1.420 653 E−04
gill (U.S.)	cubic metre (m^3)	1.182 941 E−04
grade	degree (angular)	9.000 000*E−01
grade	radian (rad)	1.570 796 E−02
grain	kilogram (kg)	6.479 891*E−05
grain/gal (U.S. liquid)	kilogram per cubic metre (kg/m^3)	1.711 806 E−02
gram	kilogram (kg)	1.000 000*E−03
g/cm^3	kilogram per cubic metre (kg/m^3)	1.000 000*E+03
gf/cm^2	pascal (Pa)	9.806 650*E+01
hectare	square metre (m^2)	1.000 000*E+04
horsepower (550 ft·lbf/s)	watt (W)	7.456 999 E+02
horsepower (boiler)	watt (W)	9.809 50 E+03
horsepower (electric)	watt (W)	7.460 000*E+02
horsepower (metric)	watt (W)	7.354 99 E+02
horsepower (water)	watt (W)	7.460 43 E+02
horsepower (U.K.)	watt (W)	7.457 0 E+02
hour	second(s)	3.600 000*E+03
hour (sidereal)	second (s)	3.590 170 E+03
ndredweight (long)	kilogram (kg)	5.080 235 E+01
ndredweight (short)	kilogram (kg)	4.535 924 E+01
ch	metre (m)	2.540 000*E−02
nch of mercury (32°F)	pascal (Pa)	3.386 38 E+03
inch of mercury (60°F)	pascal (Pa)	3.376 85 E+03
inch of water (39.2°F)	pascal (Pa)	2.490 82 E+02
inch of water (60°F)	pascal (Pa)	2.488 4 E+02
in^2	square metre (m^2)	6.451 600*E−04
in^3 (volume)[19]	cubic metre (m^3)	1.638 706 E−05
in^3 (section modulus)[19]	metre cubed (m^3)	1.638 706 E−05
in^3/min	cubic metre per second (m^3/s)	2.731 177 E−07
in^4 (second moment of area)[18]	metre to the fourth power (m^4)	4.162 314 E−07
in/s	metre per second (m/s)	2.540 000*E−02
in/s^2	metre per second squared (m/s^2)	2.540 000*E−02
kayser	1 per metre (1/m)	1.000 000*E+02
kelvin	degree Celsius (°C)	$t_C = T_K - 273.15$
kilocalorie (International Table)	joule (J)	4.186 800*E+03
kilocalorie (mean)	joule (J)	4.190 02 E+03
kilocalorie (thermochemical)	joule (J)	4.184 000*E+03
kilocalorie (thermochemical)/min	watt (W)	6.973 333 E+01
kilocalorie (thermochemical)/s	watt (W)	4.184 000*E+03
kilogram-force (kgf)	newton (N)	9.806 650*E+00
kgf·m	newton metre (N·m)	9.806 650*E+00
$kgf·s^2/m$ (mass)	kilogram (kg)	9.806 650*E+00
kgf/cm^2	pascal (Pa)	9.806 650*E+04
kgf/m^2	pascal (Pa)	9.806 650*E+00
kgf/mm^2	pascal (Pa)	9.806 650*E+06
km/h	metre per second (m/s)	2.777 778 E−01

[19] The exact conversion factor is 1.638 706 4*E−05.

To convert from	to	Multiply by
kilopond (1 kp = 1 kgf)	newton (N)	9.806 650*E+00
kW·h	joule (J)	3.600 000*E+06
1000 lbf	newton (N)	4.448 222 E+03
n^2 (ksi)	pascal (Pa)	6.894 757 E+06
(international)	metre per second (m/s)	5.144 444 E−01
lambert	candela per square metre (cd/m^2)	1/π *E+04
lambert	candela per square metre (cd/m^2)	3.183 099 E+03
langley	joule per square metre (J/m^2)	4.184 000*E+04
light year	metre (m)	9.460 55 E+15
litre[20]	cubic metre (m^3)	1.000 000*E−03
lm/ft^2	lumen per square metre (lm/m^2)	1.076 391 E+01
maxwell	weber (Wb)	1.000 000*E−08
mho	siemens (S)	1.000 000*E+00
microinch	metre (m)	2.540 000*E−08
micron (deprecated term. use micrometre)	metre (m)	1.000 000*E−06
mil	metre (m)	2.540 000*E−05
mile (international)	metre (m)	1.609 344*E+03
mile (U.S. statute)[13]	metre (m)	1.609 347 E+03
mile (international nautical)	metre (m)	1.852 000*E+03
mile (U.S. nautical)	metre (m)	1.852 000*E+03
mi^2 (international)	square metre (m^2)	2.589 988 E+06
mi^2 (U. S. statute)[13]	square metre (m^2)	2.589 998 E+06
mi/h (international)	metre per second (m/s)	4.470 400*E−01
mi/h (international)	kilometre per hour (km/h)	1.609 344*E+00
mi/min (international)	metre per second (m/s)	2.682 240*E+01
mi/s (international)	metre per second (m/s)	1.609 344*E+03
millibar	pascal (Pa)	1.000 000*E+02
millimetre of mercury (0°C)	pascal (Pa)	1.333 22 E+02
minute (angle)	radian (rad)	2.908 882 E−04
minute	second (s)	6.000 000*E+01
ute (sidereal)	second (s)	5.983 617 E+01
ted	ampere per metre (A/m)	7.957 747 E+01
n centimetre	ohm meter (Ω·m)	1.000 000*E−02
ohm circular-mil per foot	ohm metre (Ω·m)	1.662 426 E−09
ounce (avoirdupois)	kilogram (kg)	2.834 952 E−02
ounce (troy or apothecary)	kilogram (kg)	3.110 348 E−02
ounce (U.K. fluid)	cubic metre (m^3)	2.841 306 E−05
ounce (U.S. fluid)	cubic metre (m^3)	2.957 353 E−05
ounce-force	newton (N)	2.780 139 E−01
ozf·in	newton metre (N·m)	7.061 552 E−03
oz (avoirdupois)/gal (U.K. liquid)	kilogram per cubic metre (kg/m^3)	6.236 023 E+00
oz (avoirdupois)/gal (U.S. liquid)	kilogram per cubic metre (kg/m^3)	7.489 152 E+00
oz (avoirdupois)/in^3	kilogram per cubic metre (kg/m^3)	1.729 994 E+03
oz (avoirdupois)/ft^2	kilogram per square metre (kg/m^2)	3.051 517 E−01
oz (avoirdupois)/yd^2	kilogram per square metre (kg/m^2)	3.390 575 E−02
parsec	metre (m)	3.085 678 E+16
peck (U.S.)	cubic metre (m^3)	8.809 768 E−03
pennyweight	kilogram (kg)	1.555 174 E−03
perm (0°C)	kilogram per pascal second square metre [kg/(Pa·s·m^2)]	5.721 35 E−11
perm (23°C)	kilogram per pascal second square metre [kg/(Pa·s·m^2)]	5.745 25 E−11
perm·in (0°C)	kilogram per pascal second metre [kg/(Pa·s·m)]	1.453 22 E−12
perm·in (23°C)	kilogram per pascal second metre [kg/(Pa·s·m)]	1.459 29 E−12
phot	lumen per square metre (lm/m^2)	1.000 000*E+04

[20] In 1964 the General Conference on Weights and Measures reestablished the name litre as a special name for the cubic decimetre. Between 1901 and 1964 the litre was slightly larger (1.000 0.28 dm^3); in the use of high-accuracy volume data of that time interval, this fact must be kept in mind.

To convert from	to	Multiply by
pica (printer's)	metre (m)	4.217 518 E−03
pint (U.S. dry)	cubic metre (m^3)	5.506 105 E−04
pint (U.S. liquid)	cubic metre (m^3)	4.731 765 E−04
[illegible]int (printer's)	metre (m)	3.514 598*E−04
[illegible]e (absolute viscosity)	pascal second (Pa·s)	1.000 000*E−01
[illegible]nd (lb avoirdupois)[21]	kilogram (kg)	4.535 924 E−01
[illegible]nd (troy or apothecary)	kilogram (kg)	3.732 417 E−01
lb·ft^2 (moment of inertia)	kilogram square metre (kg·m^2)	4.214 011 E−02
lb·in^2 (moment of inertia)	kilogram square metre (kg·m^2)	2.926 397 E−04
lb/ft·h	pascal second (Pa·s)	4.133 789 E−04
lb/ft·s	pascal second (Pa·s)	1.488 164 E+00
lb/ft^2	kilogram per square metre (kg/m^2)	4.882 428 E+00
lb/ft^3	kilogram per cubic metre (kg/m^3)	1.601 846 E+01
lb/gal (U.K. liquid)	kilogram per cubic metre (kg/m^3)	9.977 637 E+01
lb/gal (U.S. liquid)	kilogram per cubic metre (kg/m^3)	1.198 264 E+02
lb/h	kilogram per second (kg/s)	1.259 979 E−04
lb/hp·h (SFC, specific fuel consumption)	kilogram per joule (kg/J)	1.689 659 E−07
lb/in^3	kilogram per cubic metre (kg/m^3)	2.767 990 E+04
lb/min	kilogram per second (kg/s)	7.559 873 E−03
lb/s	kilogram per second (kg/s)	4.535 924 E−01
lb/yd^3	kilogram per cubic metre (kg/m^3)	5.932 764 E−01
poundal	newton (N)	1.382 550 E−01
poundal/ft^2	pascal (Pa)	1.488 164 E+00
poundal·s/ft^2	pascal second (Pa·s)	1.488 164 E+00
pound-force (lbf)[22]	newton (N)	4.448 222 E+00
lbf·ft	newton metre (N·m)	1.355 818 E+00
lbf·ft/in	newton metre per metre (N·m/m)	5.337 866 E+01
lbf·in	newton metre (N·m)	1.129 848 E−01
lbf·in/in	newton metre per metre (N·m/m)	4.448 222 E+00
lbf·s/ft^2	pascal second (Pa·s)	4.788 026 E+01
lbf·s/in^2	pascal second (Pa·s)	6.894 757 E+03
lbf/ft	newton per metre (N/m)	1.459 390 E+01
[illegible]^2	pascal (Pa)	4.788 026 E+01
[illegible]n	newton per metre (N/m)	1.751 268 E+02
lbf/in^2 (psi)	pascal (Pa)	6.894 757 E+03
lbf/lb (thrust/weight [mass] ratio)	newton per kilogram (N/kg)	9.806 650 E+00
quart (U.S. dry)	cubic metre (m^3)	1.101 221 E−03
quart (U.S. liquid)	cubic metre (m^3)	9.463 529 E−04
rad (absorbed dose)	gray (Gy)	1.000 000*E−02
rem (dose equivalent)	sievert (Sv)	1.000 000*E−02
rhe	1 per pascal second [1/(Pa·s)]	1.000 000*E+01
rod[13]	metre (m)	5.029 210 E+00
roentgen	coulomb per kilogram (C/kg)	2.58 000*E−04
rpm (r/min)	radian per second (rad/s)	1.047 198 E−01
second (angle)	radian (rad)	4.848 137 E−06
second (sidereal)	second (s)	9.972 696 E−01
shake	second (s)	1.000 000*E−08
slug	kilogram (kg)	1.459 390 E+01
slug/ft·s	pascal second (Pa·s)	4.788 026 E+01
slug/ft^3	kilogram per cubic metre (kg/m^3)	5.153 788 E+02
statampere	ampere (A)	3.335 640 E−10
statcoulomb	coulomb (C)	3.335 640 E−10
statfarad	farad (F)	1.112 650 E−12
stathenry	henry (H)	8.987 554 E+11
statmho	siemens (S)	1.112 650 E−12
statohm	ohm (Ω)	8.987 554 E+11
statvolt	volt (V)	2.997 925 E+02

[21] The exact conversion factor is 4.535 923 7*E−01.

[22] The exact conversion factor is 4.448 221 615 260 5*E+00.

To convert from	to	Multiply by
...re	cubic metre (m^3)	1.000 000*E+00
...	candela per square metre (cd/m^2)	1.000 000*E+04
...kes (kinematic viscosity)	square metre per second (m^2/s)	1.000 000*E−04
...lespoon	cubic metre (m^3)	1.478 676 E−05
teaspoon	cubic metre (m^3)	4.928 922 E−06
tex	kilogram per metre (kg/m)	1.000 000*E−06
therm (European Community)[23]	joule (J)	1.055 06 E+08
therm (U.S.)[23]	joule (J)	1.054 804*E+08
ton (assay)	kilogram (kg)	2.916 667 E−02
ton (long, 2240 lb)	kilogram (kg)	1.016 047 E+03
ton (metric)	kilogram (kg)	1.000 000*E+03
ton (nuclear equivalent of TNT)	joule (J)	4.184 E+09[24]
ton of refrigeration (= 12 000 Btu/h)	watt (W)	3.517 E+03
ton (register)	cubic metre (m^3)	2.831 685 E+00
ton (short, 2000 lb)	kilogram (kg)	9.071 847 E+02
ton (long)/yd^3	kilogram per cubic metre (kg/m^3)	1.328 939 E+03
ton (short)/yd^3	kilogram per cubic metre (kg/m^3)	1.186 553 E+03
ton (short)/h	kilogram per second (kg/s)	2.519 958 E−01
ton-force (2000 lbf)	newton (N)	8.896 443 E+03
tonne	kilogram (kg)	1.000 000*E+03
torr (mmHg, 0°C)	pascal (Pa)	1.333 22 E+02
unit pole	weber (Wb)	1.256 637 E−07
W·h	joule (J)	3.600 000*E+03
W·s	joule (J)	1.000 000*E+00
W/cm^2	watt per square metre (W/m^2)	1.000 000*E+04
W/in^2	watt per square metre (W/m^2)	1.550 003 E+03
yard	metre (m)	9.144 000*E−01
yd^2	square metre (m^2)	8.361 274 E−01
...^{3}	cubic metre (m^3)	7.645 549 E−01
.../min	cubic metre per second (m^3/s)	1.274 258 E−02
...ar (365 days)	second (s)	3.153 600*E+07
...ear (sidereal)	second (s)	3.155 815 E+07
year (tropical)	second (s)	3.155 693 E+07

[23] The therm (European Community) is legally defined in the Council of the European Communities Directive 80/181/EC of December 20, 1979. The therm (U.S.) is legally defined in the *Federal Register*, Vol 33, No. 146, p. 10756, of July 27, 1968. Although the European therm, which is based on the International Table Btu, is frequently used by engineers in the U.S., the therm (U.S.) is the legal unit used by the U.S. natural gas industry.

[24] Defined (not measured) value.

Robert J. Todd

CLASSIFIED LIST OF UNITS

To convert from	to	Multiply by
ACCELERATION		
ft/s^2	metre per second squared (m/s^2)	3.048 000*E−01
free fall, standard (g)	metre per second squared (m/s^2)	9.806 650*E+00
gal	metre per second squared (m/s^2)	1.000 000*E−02
in/s^2	metre per second squared (m/s^2)	2.540 000*E−02
ANGLE		
degree	radian (rad)	1.745 329 E−02
minute	radian (rad)	2.908 882 E−04
second	radian (rad)	4.848 137 E−06
grade	degree (angular)	9.000 000*E−01
grade	radian (rad)	1.570 796 E−02
AREA		
acre[13]	square metre (m^2)	4.046 873 E+03
are	square metre (m^2)	1.000 000*E+02
barn	square metre (m^2)	1.000 000*E−28
circular mil	square metre (m^2)	5.067 075 E−10
ft^2	square metre (m^2)	9.290 304*E−02
hectare	square metre (m^2)	1.000 000*E+04
in^2	square metre (m^2)	6.451 600*E−04
mi^2 (international)	square metre (m^2)	2.589 988 E+06
mi^2 (U.S. statute)[13]	square metre (m^2)	2.589 998 E+06
yd^2	square metre (m^2)	8.361 274 E−01
BENDING MOMENT OR TORQUE (See 3.4.4)		
dyne·cm	newton metre (N·m)	1.000 000*E−07
kgf·m	newton metre (N·m)	9.806 650*E+00
ozf·in	newton metre (N·m)	7.061 552 E−03
lbf·in	newton metre (N·m)	1.129 848 E−01
lbf·ft	newton metre (N·m)	1.355 818 E+00
BENDING MOMENT OR TORQUE PER UNIT LENGTH		
lbf·ft/in	newton metre per metre (N·m/m)	5.337 866 E+01
lbf·in/in	newton metre per metre (N·m/m)	4.448 222 E+00
CAPACITY (See VOLUME)		
DENSITY (See MASS PER UNIT VOLUME)		
ELECTRICITY AND MAGNETISM[25]		
abampere	ampere (A)	1.000 000*E+01
abcoulomb	coulomb (C)	1.000 000*E+01
abfarad	farad (F)	1.000 000*E+09
abhenry	henry (H)	1.000 000*E−09
abmho	siemens (S)	1.000 000*E+09

[25] ESU means electrostatic cgs unit. EMU means electromagnetic cgs unit.

To convert from	to	Multiply by
abohm	ohm (Ω)	1.000 000*E−09
abvolt	volt (V)	1.000 000*E−08
ampere hour	coulomb (C)	3.600 000*E+03
EMU of capacitance	farad (F)	1.000 000*E+09
EMU of current	ampere (A)	1.000 000*E+01
EMU of electric potential	volt (V)	1.000 000*E−08
EMU of inductance	henry (H)	1.000 000*E−09
EMU of resistance	ohm (Ω)	1.000 000*E−09
ESU of capacitance	farad (F)	1.112 650 E−12
ESU of current	ampere (A)	3.335 6 E−10
ESU of electric potential	volt (V)	2.997 9 E+02
ESU of inductance	henry (H)	8.987 554 E+11
ESU of resistance	ohm (Ω)	8.987 554 E+11
faraday (based on carbon-12)	coulomb (C)	9.648 70 E+04
faraday (chemical)	coulomb (C)	9.649 57 E+04
faraday (physical)	coulomb (C)	9.652 19 E+04
gamma	tesla (T)	1.000 000*E−09
gauss	tesla (T)	1.000 000*E−04
gilbert	ampere (A)	7.957 747 E−01
maxwell	weber (Wb)	1.000 000*E−08
mho	siemens (S)	1.000 000*E+00
oersted	ampere per metre (A/m)	7.957 747 E+01
ohm centimetre	ohm metre (Ω·m)	1.000 000*E−02
ohm circular-mil per foot	ohm metre (Ω·m)	1.662 426 E−09
statampere	ampere (A)	3.335 640 E−10
statcoulomb	coulomb (C)	3.335 640 E−10
statfarad	farad (F)	1.112 650 E−12
stathenry	henry (H)	8.987 554 E+11
statmho	siemens (S)	1.112 650 E−12
statohm	ohm (Ω)	8.987 554 E+11
statvolt	volt (V)	2.997 925 E+02
unit pole	weber (Wb)	1.256 637 E−07

ENERGY (Includes WORK)

British thermal unit (International Table)[14]	joule (J)	1.055 056 E+03
British thermal unit (mean)	joule (J)	1.055 87 E+03
British thermal unit (thermochemical)	joule (J)	1.054 350 E+03
British thermal unit (39°F)	joule (J)	1.059 67 E+03
British thermal unit (59°F)	joule (J)	1.054 80 E+03
British thermal unit (60°F)	joule (J)	1.054 68 E+03
calorie (International Table)	joule (J)	4.186 800*E+00
calorie (mean)	joule (J)	4.190 02 E+00
calorie (thermochemical)	joule (J)	4.184 000*E+00
calorie (15°C)	joule (J)	4.185 80 E+00
calorie (20°C)	joule (J)	4.181 90 E+00
calorie (kilogram, International Table)	joule (J)	4.186 800*E+03
calorie (kilogram, mean)	joule (J)	4.190 02 E+03
calorie (kilogram, thermochemical)	joule (J)	4.184 000*E+03
electronvolt	joule (J)	1.602 19 E−19
erg	joule (J)	1.000 000*E−07
ft·lbf	joule (J)	1.355 818 E+00
ft-poundal	joule (J)	4.214 011 E−02
kilocalorie (International Table)	joule (J)	4.186 800*E+03
kilocalorie (mean)	joule (J)	4.190 02 E+03
kilocalorie (thermochemical)	joule (J)	4.184 000*E+03
kW·h	joule (J)	3.600 000*E+06
therm (European Community)[23]	joule (J)	1.055 06 E+08

To convert from	to	Multiply by
oz (avoirdupois)/gal (U.S. liquid)	kilogram per cubic metre (kg/m^3)	7.489 152 E+00
oz (avoirdupois)/in^3	kilogram per cubic metre (kg/m^3)	1.729 994 E+03
lb/ft^3	kilogram per cubic metre (kg/m^3)	1.601 846 E+01
lb/in^3	kilogram per cubic metre (kg/m^3)	2.767 990 E+04
lb/gal (U.K. liquid)	kilogram per cubic metre (kg/m^3)	9.977 637 E+01
lb/gal (U.S. liquid)	kilogram per cubic metre (kg/m^3)	1.198 264 E+02
lb/yd^3	kilogram per cubic metre (kg/m^3)	5.932 764 E−01
slug/ft^3	kilogram per cubic metre (kg/m^3)	5.153 788 E+02
ton (long)/yd^3	kilogram per cubic metre (kg/m^3)	1.328 939 E+03
ton (short)/yd^3	kilogram per cubic metre (kg/m^3)	1.186 553 E+03

POWER

Btu (International Table)/h	watt (W)	2.930 711 E−01
Btu (International Table)/s	watt (W)	1.055 056 E+03
Btu (thermochemical)/h	watt (W)	2.928 751 E−01
Btu (thermochemical)/min	watt (W)	1.757 250 E+01
Btu (thermochemical)/s	watt (W)	1.054 350 E+03
cal (thermochemical)/min	watt (W)	6.973 333 E−02
cal (thermochemical)/s	watt (W)	4.184 000*E+00
erg/s	watt (W)	1.000 000*E−07
ft·lbf/h	watt (W)	3.766 161 E−04
ft·lbf/min	watt (W)	2.259 697 E−02
ft·lbf/s	watt (W)	1.355 818 E+00
horsepower (550 ft·lbf/s)	watt (W)	7.456 999 E+02
horsepower (boiler)	watt (W)	9.809 50 E+03
horsepower (electric)	watt (W)	7.460 000*E+02
horsepower (metric)	watt (W)	7.354 99 E+02
horsepower (water)	watt (W)	7.460 43 E+02
horsepower (U.K.)	watt (W)	7.457 0 E+02
kilocalorie (thermochemical)/min	watt (W)	6.973 333 E+01
kilocalorie (thermochemical)/s	watt (W)	4.184 000*E+03
ton of refrigeration (= 12 000 Btu/h)	watt (W)	3.517 E+03

PRESSURE OR STRESS (FORCE PER UNIT AREA)

atmosphere, standard	pascal (Pa)	1.013 250*E+05
atmosphere, technical (= 1 kgf/cm^2)	pascal (Pa)	9.806 650*E+04
bar	pascal (Pa)	1.000 000*E+05
centimetre of mercury (0°C)	pascal (Pa)	1.333 22 E+03
centimetre of water (4°C)	pascal (Pa)	9.806 38 E+01
dyne/cm^2	pascal (Pa)	1.000 000*E−01
foot of water (39.2°F)	pascal (Pa)	2.988 98 E+03
gf/cm^2	pascal (Pa)	9.806 650*E+01
inch of mercury (32°F)	pascal (Pa)	3.386 38 E+03
inch of mercury (60°F)	pascal (Pa)	3.376 85 E+03
inch of water (39.2°F)	pascal (Pa)	2.490 82 E+02
inch of water (60°F)	pascal (Pa)	2.488 4 E+02
kgf/cm^2	pascal (Pa)	9.806 650*E+04
kgf/m^2	pascal (Pa)	9.806 650*E+00
kgf/mm^2	pascal (Pa)	9.806 650*E+06
kip/in^2 (ksi)	pascal (Pa)	6.894 757 E+06
millibar	pascal (Pa)	1.000 000*E+02
millimetre of mercury (0°C)	pascal (Pa)	1.333 22 E+02
poundal/ft^2	pascal (Pa)	1.488 164 E+00
lbf/ft^2	pascal (Pa)	4.788 026 E+01
lbf/in^2 (psi)	pascal (Pa)	6.894 757 E+03
psi	pascal (Pa)	6.894 757 E+03

To convert from	to	Multiply by
lambert	candela per square metre (cd/m^2)	3.183 099 E+03
/ft^2	lumen per square metre (lm/m^2)	1.076 391 E+01
MASS		
carat (metric)	kilogram (kg)	2.000 000*E−04
grain	kilogram (kg)	6.479 891*E−05
gram	kilogram (kg)	1.000 000*E−03
hundredweight (long)	kilogram (kg)	5.080 235 E+01
hundredweight (short)	kilogram (kg)	4.535 924 E+01
kgf·s^2/m (mass)	kilogram (kg)	9.806 650*E+00
ounce (avoirdupois)	kilogram (kg)	2.834 952 E−02
ounce (troy or apothecary)	kilogram (kg)	3.110 348 E−02
pennyweight	kilogram (kg)	1.555 174 E−03
pound (lb avoirdupois)[21]	kilogram (kg)	4.535 924 E−01
pound (troy or apothecary)	kilogram (kg)	3.732 417 E−01
slug	kilogram (kg)	1.459 390 E+01
ton (assay)	kilogram (kg)	2.916 667 E−02
ton (long, 2240 lb)	kilogram (kg)	1.016 047 E+03
ton (metric)	kilogram (kg)	1.000 000*E+03
ton (short, 2000 lb)	kilogram (kg)	9.071 847 E+02
tonne	kilogram (kg)	1.000 000*E+03
MASS PER UNIT AREA		
oz/ft^2	kilogram per square metre (kg/m^2)	3.051 517 E−01
oz/yd^2	kilogram per square metre (kg/m^2)	3.390 575 E−02
lb/ft^2	kilogram per square metre (kg/m^2)	4.882 428 E+00
MASS PER UNIT CAPACITY (See MASS PER UNIT VOLUME)		
MASS PER UNIT LENGTH		
denier	kilogram per metre (kg/m)	1.111 111 E−07
lb/ft	kilogram per metre (kg/m)	1.488 164 E+00
lb/in	kilogram per metre (kg/m)	1.785 797 E+01
lb/yd	kilogram per metre (kg/m)	E.4960 546 E−01
tex	kilogram per metre (kg/m)	1.000 000*E−06
MASS PER UNIT TIME (Includes FLOW)		
perm (0°C)	kilogram per pascal second square metre [kg/(Pa·s·m^2)]	5.721 35 E−11
perm (23°C)	kilogram per pascal second square metre [kg/(Pa·s·m^2)]	5.745 25 E−11
perm·in (0°C)	kilogram per pascal second metre [kg/(Pa·s·m)]	1.453 22 E−12
perm·in (23°C)	kilogram per pascal second metre [kg/(Pa·s·m)]	1.459 29 E−12
lb/h	kilogram per second (kg/s)	1.259 979 E−04
lb/min	kilogram per second (kg/s)	7.559 873 E−03
lb/s	kilogram per second (kg/s)	4.535 924 E−01
lb/(hp·h) (SFC, specific fuel consumption)	kilogram per joule (kg/J)	1.689 659 E−07
ton (short)/h	kilogram per second (kg/s)	2.519 958 E−01
MASS PER UNIT VOLUME (Includes DENSITY and MASS CAPACITY)		
lb/gal (U.S. liquid)	kilogram per cubic metre (kg/m^3)	1.711 806 E−02
g/cm^3	kilogram per cubic metre (kg/m^3)	1.000 000*E+03
lb (avoirdupois)/gal (U.K. liquid)	kilogram per cubic metre (kg/m^3)	6.236 023 E+00

To convert from	to	Multiply by
Btu (International Table)/(s·ft²·°F)	watt per square metre kelvin [W/(m²·K)]	2.044 175 E+04
Btu (thermochemical)/(s·ft²·°F)	watt per square metre kelvin [W/(m²·K)]	2.042 808 E+04
Btu (International Table)/lb	joule per kilogram (J/kg)	2.326 000*E+03
Btu (thermochemical)/lb	joule per kilogram (J/kg)	2.324 444 E+03
Btu (International Table)/(lb·°F) (heat capacity)	joule per kilogram kelvin [J/(kg·K)]	4.186 800*E+03
Btu (thermochemical)/(lb·°F) (heat capacity)	joule per kilogram kelvin [J/(kg·K)]	4.184 000*E+03
Btu (International Table)/ft³	joule per cubic metre (J/m³)	3.725 895 E+04
Btu (thermochemical)/ft³	joule per cubic metre (J/m³)	3.723 402 E+04
cal (thermochemical)/(cm·s·°C)	watt per metre kelvin [W/(m·K)]	4.184 000*E+02
cal (thermochemical)/cm²	joule per square metre (J/m²)	4.184 000*E+04
cal (thermochemical)/(cm²·min)	watt per square metre (W/m²)	6.973 333 E+02
cal (thermochemical)/(cm²·s)	watt per square metre (W/m²)	4.184 000*E+04
cal (International Table)/g	joule per kilogram (J/kg)	4.186 800*E+03
cal (thermochemical)/g	joule per kilogram (J/kg)	4.184 000*E+03
cal (International Table)/(g·°C)	joule per kilogram kelvin [J/(kg·K)]	4.186 800*E+03
cal (thermochemical)/(g·°C)	joule per kilogram kelvin [J/(kg·K)]	4.184 000*E+03
cal (thermochemical)/min	watt (W)	6.973 333 E−02
cal (thermochemical)/s	watt (W)	4.184 000*E+00
clo	kelvin square metre per watt (K·m²/W)	1.55 E−01
°F·h·ft²/Btu (International Table) (thermal resistance)[17]	kelvin square metre per watt (K·m²/W)	1.761 102 E−01
°F·h·ft²/Btu (thermochemical) (thermal resistance)[17]	kelvin square metre per watt (K·m²/W)	1.762 280 E−01
°F·h·ft²/[Btu (International Table)·in] (thermal resistivity)	kelvin metre per watt (K·m/W)	6.933 471 E+00
°F·h·ft²/[Btu (thermochemical)·in] (thermal resistivity)	kelvin metre per watt (K·m/W)	6.938 113 E+00
ft²/h (thermal diffusivity)	square metre per second (m²/s)	2.580 640*E−05

LENGTH

angstrom	metre (m)	1.000 000*E−10
astronomical unit	metre (m)	1.495 979 E+11
chain[13]	metre (m)	2.011 684 E+01
fathom[13]	metre (m)	1.828 804 E+00
fermi (femtometre)	metre (m)	1.000 000*E−15
foot	metre (m)	3.048 000*E−01
foot (U.S. survey)[13]	metre (m)	3.048 006 E−01
inch	metre (m)	2.540 000*E−02
light year	metre (m)	9.460 55 E+15
microinch	metre (m)	2.540 000*E−08
micron (deprecated term, use micrometre)	metre (m)	1.000 000*E−06
mil	metre (m)	2.540 000*E−05
mile (international nautical)	metre (m)	1.852 000*E+03
mile (U.S. nautical)	metre (m)	1.852 000*E+03
mile (international)	metre (m)	1.609 344*E+03
mile (U.S. statute)[13]	metre (m)	1.609 347 E+03
parsec	metre (m)	3.085 678 E+16
pica (printer's)	metre (m)	4.217 518 E−03
point (printer's)	metre (m)	3.514 598*E−04
rod[13]	metre (m)	5.029 210 E+00
yard	metre (m)	9.144 000*E−01

LIGHT

cd/in²	candela per square metre (cd/m²)	1.550 003 E+03
footcandle	lux (lx)	1.076 391 E+01
footlambert	candela per square metre (cd/m²)	3.426 259 E+00

To convert from	to	Multiply by
therm (U.S.)[23]	joule (J)	1.054 804*E+08
ton (energy equivalent of TNT)	joule (J)	4.184 E+09[24]
W·h	joule (J)	3.600 000*E+03
	joule (J)	1.000 000*E+00

ENERGY PER UNIT AREA TIME

Btu (International Table)/(ft²·s)	watt per square metre (W/m²)	1.135 653 E+04
Btu (International Table)/(ft²·h)	watt per square metre (W/m²)	3.154 591 E+00
Btu (thermochemical)/(ft²·s)	watt per square metre (W/m²)	1.134 893 E+04
Btu (thermochemical)/(ft²·min)	watt per square metre (W/m²)	1.891 489 E+02
Btu (thermochemical)/(ft²·h)	watt per square metre (W/m²)	3.152 481 E+00
Btu (thermochemical)/(in²·s)	watt per square metre (W/m²)	1.634 246 E+06
cal (thermochemical)/(cm²·min)	watt per square metre (W/m²)	6.973 333 E+02
cal (thermochemical)/(cm²·s)	watt per square metre (W/m²)	4.184 000*E+04
erg/(cm²·s)	watt per square metre (W/m²)	1.000 000*E−03
W/cm²	watt per square metre (W/m²)	1.000 000*E+04
W/in²	watt per square metre (W/m²)	1.550 003 E+03

FLOW (See MASS PER UNIT TIME or VOLUME PER UNIT TIME)

FORCE

dyne	newton (N)	1.000 000*E−05
kilogram-force	newton (N)	9.806 650*E+00
kilopond (kp)	newton (N)	9.806 650*E+00
kip (1000 lbf)	newton (N)	4.448 222 E+03
ounce-force	newton (N)	2.780 139 E−01
pound-force (lbf)[22]	newton (N)	4.448 222 E+00
lbf/lb (thrust/weight [mass] ratio)	newton per kilogram (N/kg)	9.806 650 E+00
poundal	newton (N)	1.382 550 E−01
ton-force (2000 lbf)	newton (N)	8.896 443 E+03

FORCE PER UNIT AREA (See PRESSURE)

FORCE PER UNIT LENGTH

lbf/ft	newton per metre (N/m)	1.459 390 E+01
lbf/in	newton per metre (N/m)	1.751 268 E+02

HEAT

Btu (International Table)·ft/(h·ft²·°F) (thermal conductivity)	watt per metre kelvin [W/(m·K)]	1.730 735 E+00
Btu (thermochemical)·ft/(h·ft²·°F) (thermal conductivity)	watt per metre kelvin [W/(m·K)]	1.729 577 E+00
Btu (International Table)·in/(h·ft²·°F) (thermal conductivity)	watt per metre kelvin [W/(m·K)]	1.442 279 E−01
Btu (thermochemical)·in(h·ft²·°F) (thermal conductivity)	watt per metre kelvin [W/(m·K)]	1.441 314 E−01
Btu (International Table)·in/(s·ft²·°F) (thermal conductivity)	watt per metre kelvin [W/(m·K)]	5.192 204 E+02
Btu (thermochemical)·in/(s·ft²·°F) (thermal conductivity)	watt per metre kelvin [W/(m·K)]	5.188 732 E+02
Btu (International Table)/ft²	joule per square metre (J/m²)	1.135 653 E+04
Btu (thermochemical)/ft²	joule per square metre (J/m²)	1.134 893 E+04
Btu (International Table)/(h·ft²·°F) (thermal conductance)[15]	watt per square metre kelvin [W/(m²·K)]	5.678 263 E+00
Btu (thermochemical)/(h·ft²·°F) (thermal conductance)[15]	watt per square metre kelvin [W/(m²·K)]	5.674 466 E+00

To convert from	to	Multiply by
torr (mmHg, 0°C)	pascal (Pa)	1.333 22 E+02

RADIATION UNITS

curie	becquerel (Bq)	3.700 000*E+10
rad	gray (Gy)	1.000 000*E−02
rem	sievert (Sv)	1.000 000*E−02
roentgen	coulomb per kilogram (C/kg)	2.580 000*E−04

SPEED (See VELOCITY)

STRESS (See PRESSURE)

TEMPERATURE

degree Celsius	kelvin (K)	$T_K = t_c + 273.15$
degree Fahrenheit	degree Celsius (°C)	$t_c = (t_F - 32)/1.8$
degree Fahrenheit	kelvin (K)	$T_K = (t_F + 459.67)/1.8$
degree Rankine	kelvin (K)	$T_K = T_R/1.8$
kelvin	degree Celsius (°C)	$t_c = T_K - 273.15$

TIME

day	second (s)	8.640 000*E+04
day (sidereal)	second (s)	8.616 409 E+04
hour	second (s)	3.600 000*E+03
hour (sidereal)	second (s)	3.590 170 E+03
minute	second (s)	6.000 000*E+01
minute (sidereal)	second (s)	5.983 617 E+01
second (sidereal)	second (s)	9.972 696 E−01
year (365 days)	second (s)	3.153 600*E+07
year (sidereal)	second (s)	3.155 815 E+07
year (tropical)	second (s)	3.155 693 E+07

TORQUE (See BENDING MOMENT)

VELOCITY (Includes SPEED)

ft/h	metre per second (m/s)	8.466 667 E−05
ft/min	metre per second (m/s)	5.080 000*E−03
ft/s	metre per second (m/s)	3.048 000*E−01
in/s	metre per second (m/s)	2.540 000*E−02
km/h	metre per second (m/s)	2.777 778 E−01
knot (international)	metre per second (m/s)	5.144 444 E−01
mi/h (international)	metre per second (m/s)	4.470 400*E−01
mi/min (international)	metre per second (m/s)	2.682 240*E+01
mi/s (international)	metre per second (m/s)	1.609 344*E+03
mi/h (international)	kilometre per hour (km/h)[26]	1.609 344*E+00
rpm (r/min)	radian per second (rad/s)	1.047 198 E−01

VISCOSITY

centipoise (dynamic viscosity)	pascal second (Pa·s)	1.000 000*E−03
centistokes (kinematic viscosity)	square metre per second (m^2/s)	1.000 000*E−06
ft^2/s	square metre per second (m^2/s)	9.290 304*E−02
poise	pascal second (Pa·s)	1.000 000*E−01
poundal·s/ft^2	pascal second (Pa·s)	1.488 164 E+00
lb/(ft·h)	pascal second (Pa·s)	4.133 789 E−04
lb/(ft·s)	pascal second (Pa·s)	1.488 164 E+00
lbf·s/ft^2	pascal second (Pa·s)	4.788 026 E+01

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To convert from	to	Multiply by
lbf·s/in²	pascal second (Pa·s)	6.894 757 E+03
rh	l per pascal second [1/(Pa·s)]	1.000 000*E+01
sl (·s)	pascal second (Pa·s)	4.788 026 E+01
st	square metre per second (m²/s)	1.000 000*E−04

VOLUME (Includes CAPACITY)

acre-foot[13]	cubic metre (m³)	1.233 489 E+03
barrel (oil, 42 gal)	cubic metre (m³)	1.589 873 E−01
board foot	cubic metre (m³)	2.359 737 E−03
bushel (U.S.)	cubic metre (m³)	3.523 907 E−02
cup	cubic metre (m³)	2.365 882 E−04
ounce (U.S. fluid)	cubic metre (m³)	2.957 353 E−05
ft³	cubic metre (m³)	2.831 685 E−02
gallon (Canadian liquid)	cubic metre (m³)	4.546 090 E−03
gallon (U.K. liquid)	cubic metre (m³)	4.546 092 E−03
gallon (U.S. dry)	cubic metre (m³)	4.404 884 E−03
gallon (U.S. liquid)	cubic metre (m³)	3.785 412 E−03
gill (U.K.)	cubic metre (m³)	1.420 653 E−04
gill (U.S.)	cubic metre (m³)	1.182 941 E−04
in³ [see footnote 19]	cubic metre (m³)	1.638 706 E−05
litre [see footnote 20]	cubic metre (m³)	1.000 000*E−03
ounce (U.K. fluid)	cubic metre (m³)	2.841 306 E−05
ounce (U.S. fluid)	cubic metre (m³)	2.957 353 E−05
peck (U.S.)	cubic metre (m³)	8.809 768 E−03
pint (U.S. dry)	cubic metre (m³)	5.506 105 E−04
pint (U.S. liquid)	cubic metre (m³)	4.731 765 E−04
quart (U.S. dry)	cubic metre (m³)	1.101 221 E−03
c (U.S. liquid)	cubic metre (m³)	9.463 529 E−04
s	cubic metre (m³)	1.000 000*E+00
t spoon	cubic metre (m³)	1.478 676 E−05
teaspoon	cubic metre (m³)	4.928 922 E−06
ton (register)	cubic metre (m³)	2.831 685 E+00
yd³	cubic metre (m³)	7.645 549 E−01

VOLUME PER UNIT TIME (Includes FLOW)

ft³/min	cubic metre per second (m³/s)	4.719 474 E−04
ft³/s	cubic metre per second (m³/s)	2.831 685 E−02
gallon (U.S. liquid)/(hp·h)(SFC, specific fuel consumption)	cubic metre per joule (m³/J)	1.410 089 E−09
in³/min	cubic metre per second (m³/s)	2.731 177 E−07
yd³/min	cubic metre per second (m³/s)	1.274 258 E−02
gallon (U.S. liquid) per day	cubic metre per second (m³/s)	4.381 264 E−08
gallon (U.S. liquid) per minute	cubic metre per second (m³/s)	6.309 020 E−05

WORK (See ENERGY)

[26] Although speedometers may read km/h, the SI unit is m/s.

CHAPTER 2: PROCEDURE FOR ADVISORY SPEED ZONES

SECTION 1: CURVES AND TURNS

12-101 CALCULATIONS

Calculate the maximum safe design speed of the curve under consideration using the formula:

$$V = \sqrt{15R\,(e + f)}$$

where

V = vehicle speed in m.p.h.
R = radius of curve in feet
e = rate of roadway superelevation in feet per foot
f = side friction factor

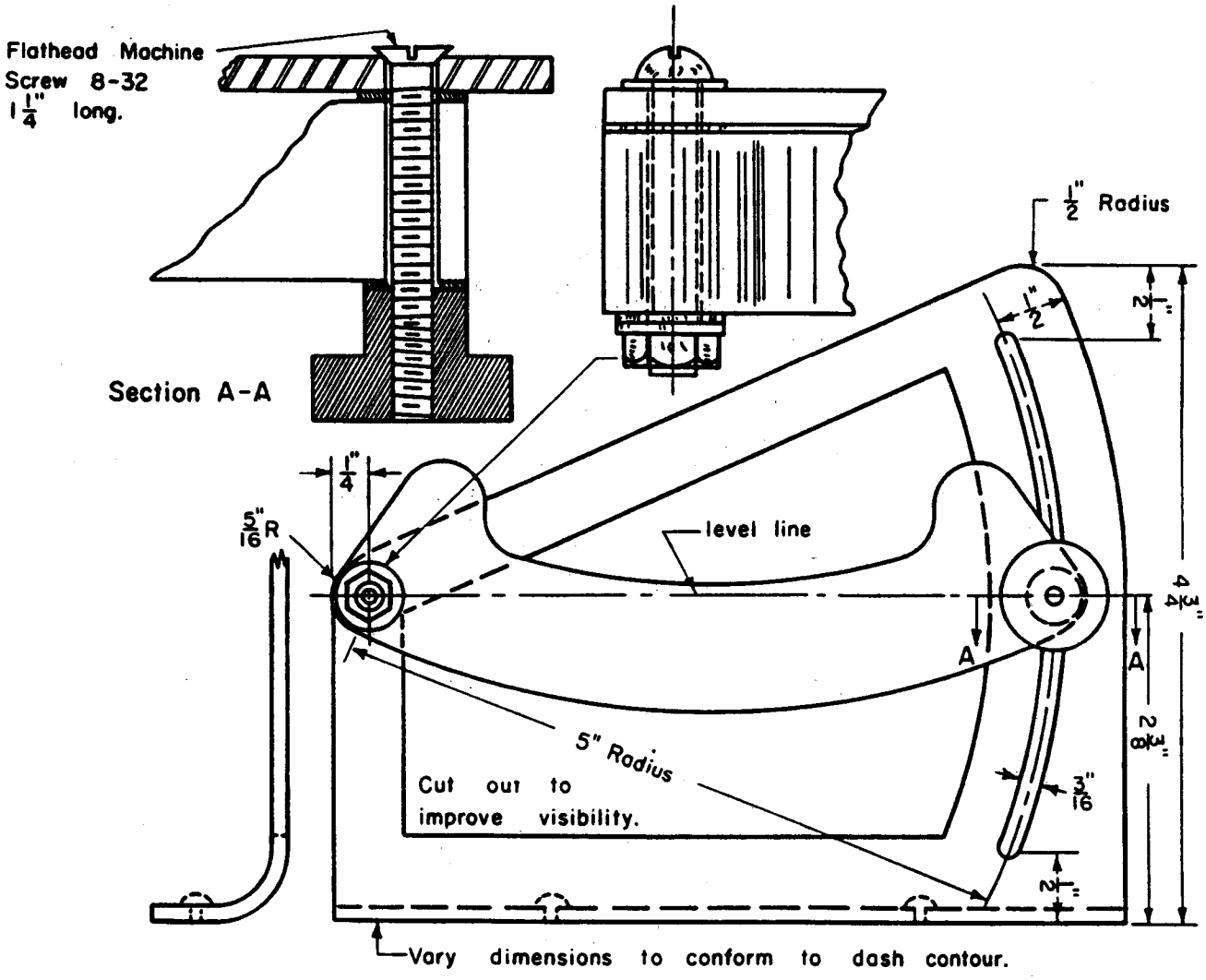
Use values of "f" = 0.15 for speeds 35 m.p.h. and over, 0.18 for speeds between 20 and 35 m.p.h., and 0.31 for speeds 20 m.p.h. and less. Values of "R" and "e" may be obtained from the roadway construction plans. Those curves and turns with maximum safe speeds of 10 m.p.h. or more below the statewide maximum or legal speed limit need to be zoned, and others may be zoned. The calculated speed is to be used as a guide for making the initial trial speed run and as a check on the speed obtained by the use of the ball bank indicator, but it is not to be used as the basis for selecting the speed to be posted.

12-102 SELECTION OF CAR AND MOUNTING OF BALL BANK INDICATOR

Select an average passenger car for making the test runs and mount the ball bank indicator on the center line of the dash. Suitable metal strap mountings can be made on which to mount the indicator, as shown on Figure 1-1. The metal strap holding the right-hand side of the indicator on dash mountings should be slotted and a thumb nut provided so the steel ball can be adjusted to the zero degree position by raising or lowering the right side of the indicator. If there is any doubt about the selection of an average car, a ball bank indicator should be mounted on three different makes or year models for a check.

SUGGESTED MOUNTING FOR BALL-BANK INDICATOR ON DASH

FIGURE 1-1



12-103 CALIBRATION OF SPEEDOMETER

Calibrate the speedometer for recording of speed. The accuracy of the odometer for recording distance should be checked against a measured distance. Calibration for speed can be done easily with a radar speed meter or by timing the car over a measured distance, preferably 176 feet, using stop watches and mirror boxes. The speedometer should be checked for each 5 m.p.h. interval over 20 m.p.h., and several test runs should be made for each speed so that an average value may be obtained. IT IS ESSENTIAL THAT SPEEDOMETERS BE CALIBRATED ACCURATELY IF THERE IS TO BE ANY DEGREE OF UNIFORMITY OF POSTED SPEEDS THROUGHOUT THE STATE.

12-104 USE OF THE BALL BANK INDICATOR

12-104.1 Tire Inflation

Inflate all tires to the uniform pressure used during speedometer calibration.

12-104.2 Zeroing Ball Bank Indicator

With the car straddling the center line of the pavement on a tangent section to give the effect of a flat level surface and the driver and recorder in the same position in which they will ride during the test runs, adjust the ball bank indicator to the zero reading. It is essential that the driver and recorder be in the same position when the ball bank indicator is set to zero reading as they will be when test runs are made, because a shift in the load is reflected in a change of the ball bank indicator reading.

12-104.3 Test Runs

The curve should be driven at the calculated speed described in paragraph 12-101 on the initial run. If the calculated speed is not available, the curve should be driven at an estimated speed approximately 5 m.p.h. slower than that which the driver feels he can maintain throughout the entire length of the curve. Each succeeding run should be made at a speed of 5 m.p.h. greater than the preceding one until the ball bank indicator reading has reached 10 degrees for curves good for 35 m.p.h. or more, 12 degrees for 25 and 30 m.p.h., and 14 degrees for 20 m.p.h. and less. On each test run, the driver should reach his trial run speed at a distance of

at least one-quarter mile from the beginning of the curve and maintain this speed throughout the entire length of the curve. The path of the car throughout the curve should be maintained as nearly as possible in the center of the right-hand lane. Test runs should be made in each direction on each curve. The observer shall, on each of the speeds of the trial runs described above, note carefully the position of the ball throughout the length of the curve and record the maximum deflection in degrees that occurs. He should interpolate the readings as closely as possible to the nearest degree.

12-104.4 Alternate for Test Runs

After the instructions in paragraphs 12-104.1 and 12-104.2 have been complied with, an alternate for the instructions in paragraph 12-104.3 may be used which will minimize the number of trial runs required to determine the speed for which the curve is to be posted. This alternate procedure is as follows:

(1) Drive the car at a speed of about 5 m.p.h. around the curve, staying as nearly as possible in the center of the right-hand lane, and record the maximum deflection of the ball bank indicator in degrees. The reading of the ball bank indicator should be recorded as plus if the deflection of the ball is to the right on a right-hand curve and to the left on a left-hand curve. The reading of the ball bank indicator should be recorded as minus if the deflection of the ball is to the left on a right-hand curve and to the right on a left-hand curve.

(2) Drive around the curve at a constant speed which can be maintained without acceleration or deceleration and without driving outside the right-hand traffic lane. Record the maximum deflection of the ball bank indicator and the speed at which the curve was driven.

(3) Compute the safe speed using the formula:

$$\frac{V_1}{V_2} = \sqrt{\frac{\theta_1 + (\pm\emptyset)}{\theta_2 + (\pm\emptyset)}}$$

where

θ_1 = maximum ball bank reading as recorded from procedure outlined in paragraph (2).

θ_2 = 10° for 35 m.p.h. and over, 12° for 21 through 34 m.p.h., and 14° for 20 m.p.h. and less.

ϕ = ball bank indicator reading as recorded from procedure outlined in paragraph (1).

V_1 = speed in m.p.h. at which θ_1 was recorded from procedure outlined in paragraph (2).

V_2 = calculated safe speed in m.p.h. for which curve is good.

(4) Drive around the curve, staying in right-hand lane, at the calculated speed V_2 without acceleration or deceleration as a check on measurements and computations. The ball bank indicator record at speed V_2 should then be 10° for 35 m.p.h., and 14° for 20 m.p.h. and less.

12-105 SELECTING SPEED FOR POSTING

The speed to be posted shall be based on the results obtained from the trial runs with the ball bank indicator, not the calculated value, and it shall be a multiple of 5 m.p.h. A ball bank indicator reading of 14 degrees shall be used for curves 20 m.p.h. and less, 12 degrees for 25 and 30 m.p.h., and 10 degrees for 35 m.p.h. and over. In selecting the speed to be posted, care should be taken that the calibrated speed for any given speedometer reading is used rather than the speedometer reading itself. As a final check, the posted speed is aimed at the highest value that will permit the average car to travel around the curve in its own lane without causing an uncomfortable side throw to its passengers. THE SPEED TO BE POSTED ON THE CURVE SHOULD NOT BE REDUCED ARBITRARILY BELOW THAT DETERMINED BY THE OUTLINED PROCEDURE.

THESE SIGNS MUST MEAN WHAT THEY SAY TO BE EFFECTIVE. When there is a reverse curve or a series of three or more curves, the Advisory Speed sign shall show the value for the curve having the slowest safe speed in the series.

SECTION 2: OTHER LOCATIONS

12-201 INTERSECTIONS

The speed to be posted for the rotary roadway of a circle shall be determined in the same manner as that outlined for curves. At intersections having view obstructions, the safe approach speed shall be calculated by the methods outlined in the latest edition of the AASHTO book A Policy on Geometric Design of Rural Highways.

12-202 NARROW AND ONE-LANE BRIDGES

To determine the speed for posting at such structures, the horizontal and/or vertical sight distance should first be measured and the safe approach speed calculated by the use of the formula:

$$d = 2.93V + 0.083V^2$$

where

d = sight distance or safe stopping distance in feet

V = the velocity in m.p.h.

This formula is based on a total perception and brake reaction time of 2 seconds and a coefficient of friction of 0.4. Both this formula and the method for measuring sight distance are given in the AASHTO book A Policy on Geometric Design of Rural Highways.

The normal location of the W5-2 NARROW BRIDGE or W5-3 ONE LANE BRIDGE signs, under which a W13-1 or SW13-1 ADVISORY SPEED sign would be mounted, is specified in the latest edition of the Texas Manual on Uniform Traffic Control Devices for Streets and Highways. The signs may be located at a greater distance in advance of the bridge if necessary to allow sufficient time and distance for deceleration, and may be repeated at the point where the structure first comes into view.

12-203 DESCENDING GRADES OF 6 PER CENT OR OVER

The minimum horizontal and vertical sight distances on descending grades of 6 per cent or over should be determined either by field measurements or by calculations from the plans, and using this minimum sight distance as the safe stopping distance, the critical speed should be calculated from the formula:

$$d = \frac{V^2}{30(0.4 \pm \text{grade})} + 2.93V$$

where

d = sight distance or safe stopping distance in feet

V = the velocity in m.p.h.

grade = per cent of grade divided by 100

Should there be a curve within the limits of or at the bottom of such grades, the critical speed for the curve should be determined by the procedure outlined under Section 1 of this Chapter.

The speed to be posted should be the lower of the two speeds found for providing a safe stopping distance and that for safe travel around the curve.

12-204 DIPS

The speed to be posted for dips shall be determined by trial runs. It should be the highest speed that will enable a vehicle to travel over the dip without considerable discomfort to passengers, without causing a shifting of cargo, or without causing a deflection of a vehicle from its true course.

SECTION 3: SIGNING

12-301 SIGN DESIGN

Signs for Advisory speed zones shall be the W13-1 or SW13-1 design as shown in the latest edition of the Texas Manual on Uniform Traffic Control Devices for Streets and Highways. THIS SIGN SHALL BE USED ONLY IN CONJUNCTION WITH STANDARD WARNING SIGNS.

12-302 SIGN POSTING

The W13-1 or SW13-1 ADVISORY SPEED sign may be used in conjunction with any standard Warning sign to indicate the maximum safe speed for passenger cars around a curve or through a hazardous location. It shall not be used in conjunction with any sign other than a Warning sign, nor shall it be used alone.

The W13-1 or SW13-1 sign shall always be mounted on the same post with and immediately below the Warning sign to which it applies. The W13-1 sign shall be used with Warning signs smaller than 36 inches by 36 inches. The SW13-1 sign shall be used with Warning signs, 36 inches by 36 inches and larger.

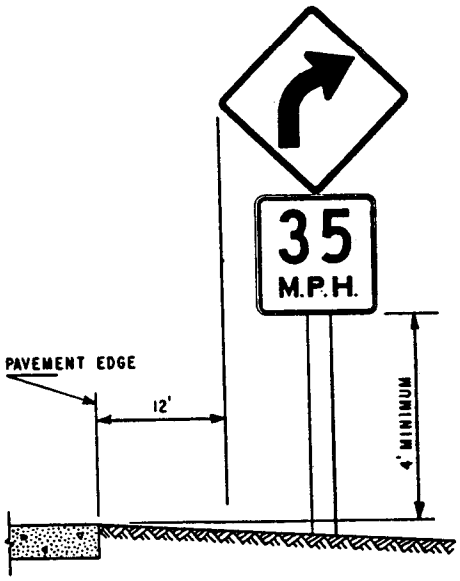
The W13-1 or SW13-1 sign is classed with the Warning signs because when used, it is in effect a part of a Warning sign.

See Figures 1-2 and 1-3 for typical signing applications.

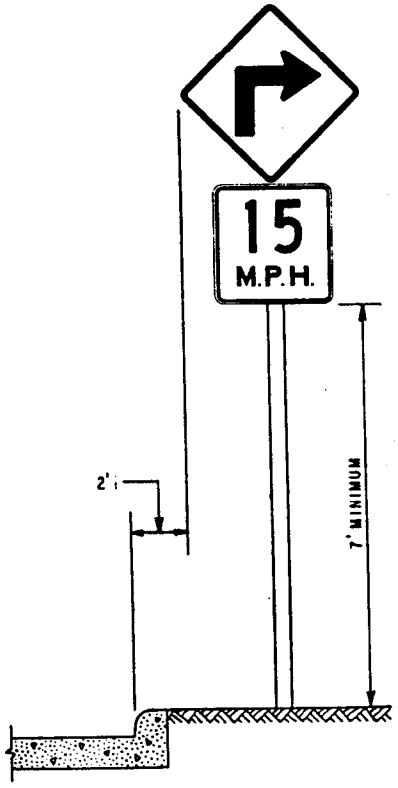
TYPICAL HEIGHT AND LOCATION

Roadside Warning Signs

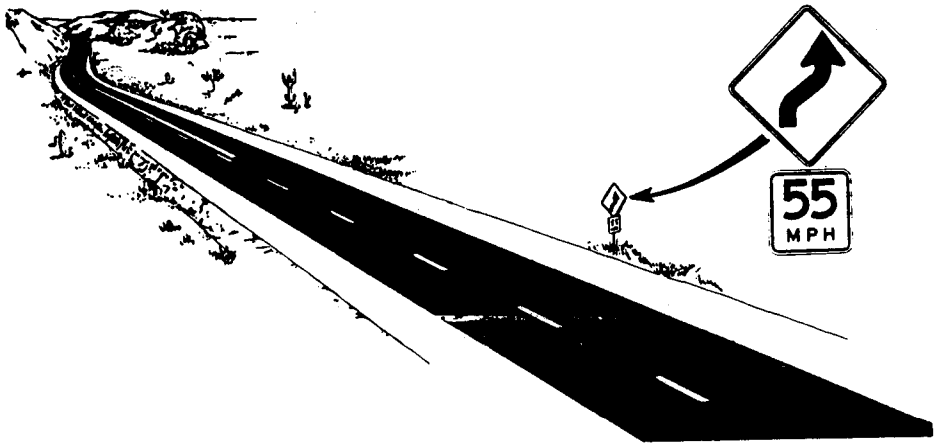
FIGURE 1-2



CURVE SIGN
Rural District
Conventional Highways



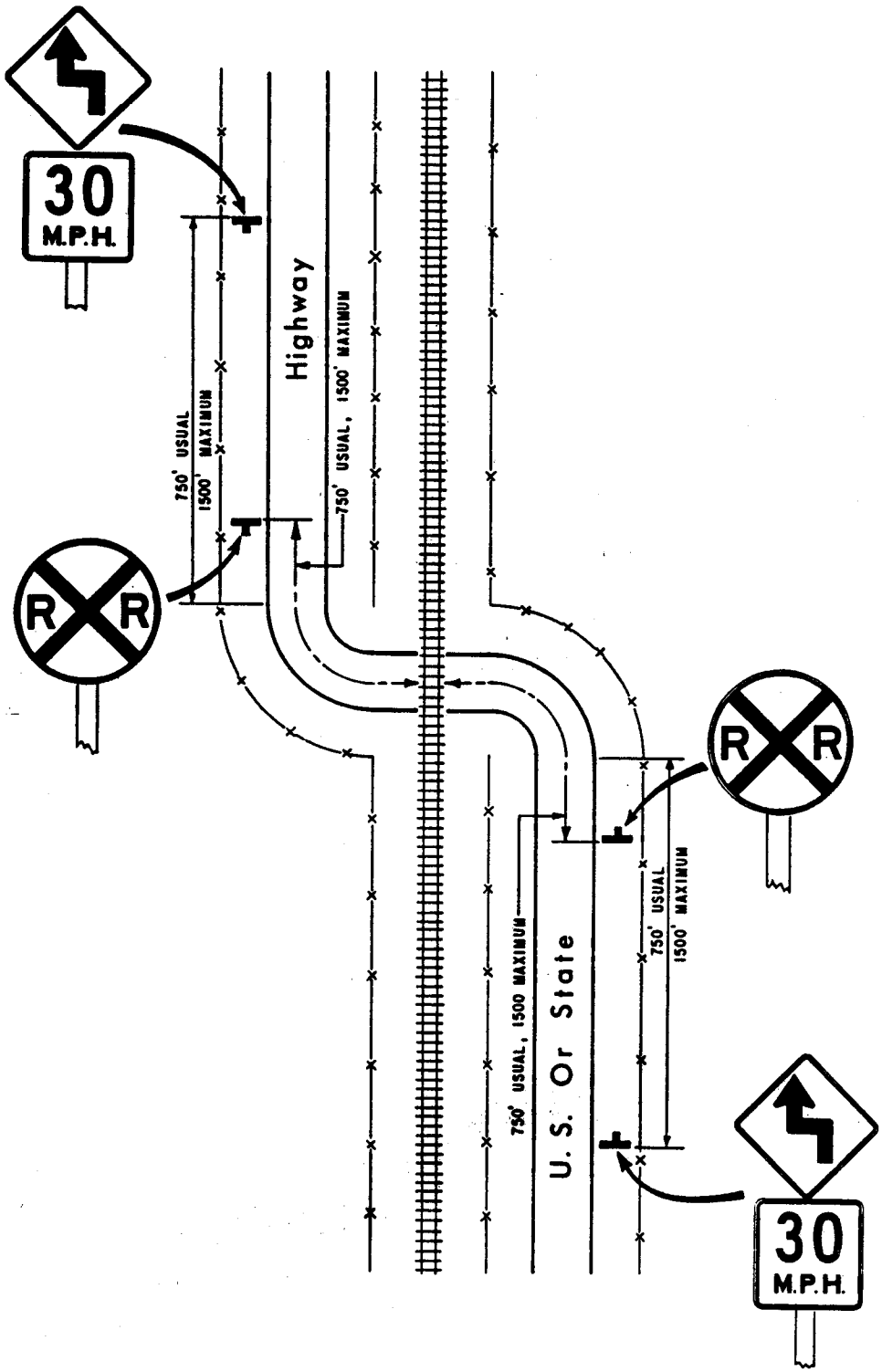
TURN SIGN
Business or Residence District



TYPICAL APPLICATIONS OF WARNING SIGNS

Rural Districts

FIGURE 1-3



MEMORANDUM **UTAH DEPARTMENT OF TRANSPORTATION**

DATE: **May 29, 2002**

TO: Clark Mackay, P.E.
Region 4 Preconstruction Engineer

FROM: John Leonard, P.E.
Traffic Operations Engineer

SUBJECT: Clear Zone and Auxiliary Lanes

The Division of Traffic and Safety has been requested to review the location of the AASHTO Clear Zone in respect to Auxiliary Lanes. Specifically, the issue has been raised as to where the clear zone begins: at the point separating the through lane from the auxiliary lane; or at the shoulder line of the auxiliary lane.

An auxiliary lane is defined in the 2001 AASHTO *Policy on Geometric Design of Highways and Streets* as "...the portion of the roadway adjoining the traveled way for speed change, turning, storage for turning, weaving, truck climbing, and other purposes supplementary to through-traffic movement." This infers that the traffic on the auxiliary lane is proceeding at a speed significantly less than the prevailing speed of the through-traffic movement, since maneuvers are taking place. In this instance, it is appropriate to allow the clear zone to be calculated from the point between the through-traffic lane and the auxiliary lane. Engineering judgment may still be used to extend this clear zone based upon the individual situation and site conditions.

An exception to this determination is the passing lanes installed on many of our uphill facilities, which are mistakenly called 'truck climbing' lanes. We do not dedicate these lanes solely to truck use; in fact, we require all motorists to use the right lane except to pass, and often post regulatory signs to remind the motorist of this. Both lanes should be treated as through-traffic lanes, and the outside one is not to be considered an auxiliary lane for determination of the clear zone. In this instance, it is proper to calculate the clear zone distance from the shoulder line, since the traffic is moving in this lane at the posted speed. Additionally, any other lane that is operating at the posted speed, such as the 'auxiliary lanes' between interchanges on I-15 in Salt Lake, should also have the clear zone measured from the shoulder line.

Please let us know if you have any additional questions.

JLL/jll

cc: Rex Harris, David Kennison, R-1; Betty Purdie, Mack Christensen, R-2; Merrell Jolley, Doug Bassett, R-3; Troy Torgerson, R-4; Jason Davis, Robert Hull, File

Memorandum UTAH DEPARTMENT OF TRANSPORTATION

September 26, 1994

To: Members of the Traffic Engineering Panel

From: David A. Kinnecom, P.E. DAK
Traffic Management Engineer

Re: Trial of Concrete Junction Boxes/Cast Iron Covers

Listed below are new ID numbers for concrete junction boxes and cast iron covers.

Material ID	Description
91616-4	Fiberglass reinforced concrete box with fiberglass reinforced concrete lid
91615-6	Fiberglass reinforced concrete box with steel lid
91613-1	Cast iron 12" X 18" frame and solid lid

The Traffic Signal Lab has been using these on a trial basis in the following applications:

1. Fiberglass reinforced concrete box with fiberglass reinforced concrete lid. These are being primarily used in areas with pedestrian traffic to replace plastic boxes have failed due to occasional vehicle loads.

2. Fiberglass reinforced concrete box with steel lid. These have been used to replace plastic boxes in areas with more frequent vehicle loads such in planting strips adjacent to driveways.

3. Cast iron 12" X 18" frame and solid lid. These have been used to date only to repair failed plastic boxes in driveways subject to regular heavy vehicle vehicle loads. The frames are being set on a concrete collar placed around the top of existing plastic boxes. I can supply a detail of this if required.

Open-end contracts are now in place to purchase these three items as needed.

cc:

Eric Cheng	Mack Christensen	Sterling Davis
Zeke Gonzalez	Dave Kennison	John Leonard
Fred Lewis	Tamerha Maxwell	John Nye
Brian Phillips	Joe Reaveley	Tim Rose
Basharat Siddiqi	Dale Stapley	Matt Swapp
Dan Washburn		